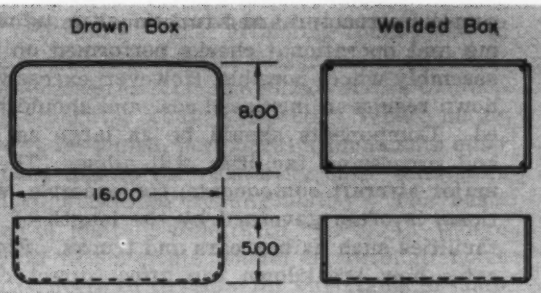


Analysis		
	Drawn box	Welded box
Tooling Total cost	450.00	57.00
Manufacturing Cost—part	.04	.70
Total	See cost comparison curve	

Fig. 1—Simple box design with break-even curve illustrates how design quantity can affect the design choice

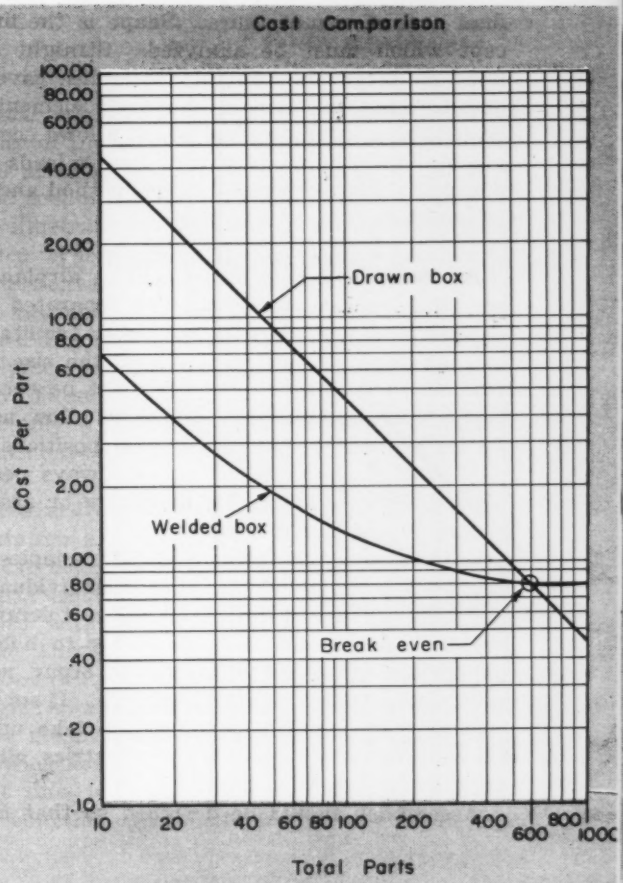
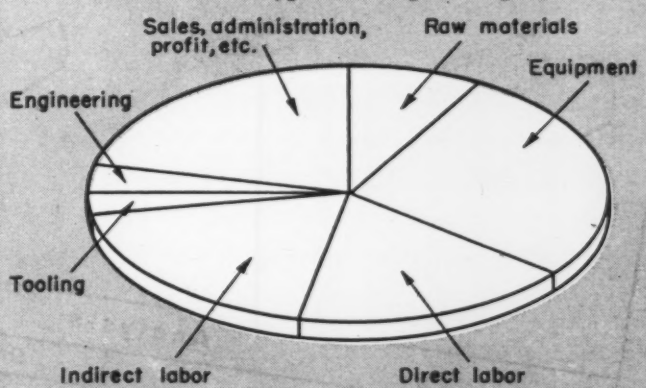


Fig. 2—Below—Chart showing cost breakdown for a typical transport airplane



istrative, direct and indirect labor comprise approximately 70 per cent of total airframe cost for a typical transport airplane.[2] An analysis of fighter types yields a similar figure. Obviously, since the total design time is limited, the design emphasis must be toward reducing the total man hours required to build the product. It would be unwise, however, to ignore the cost of new materials and equipment. They are a significant part of any product even though their cost is usually a smaller percentage of the total. Substantial savings can be achieved through their careful consideration although less time need be spent on their analysis.

Reducing the total number of parts saves assembly time and minimizes assembly problems. Fewer parts also means less indirect labor in proportion—fewer tool orders, fabrication orders, etc., need be written. It is often desirable to increase fabrication time on detail components where substantial amounts of assembly time can be saved. This is always premised on a reduction in the overall number of direct and indirect man hours, and the possible reduction of the floor space required to fabricate and assemble the product.

Production Design Principles: In the development of a design, certain principles should be observed to guarantee the ultimate simpliciy and best producibility. These principles are general in nature and apply equally to any design element whether it is as simple as a "kiddy kar" or as complex as an airplane. Design illustrations are taken from aircraft only because this is the author's basic field. Numerous similar illustrations exist in every type of product.

Basic Arrangement: The first consideration in any design is the basic arrangement of the product to be produced, since it has a marked effect on the

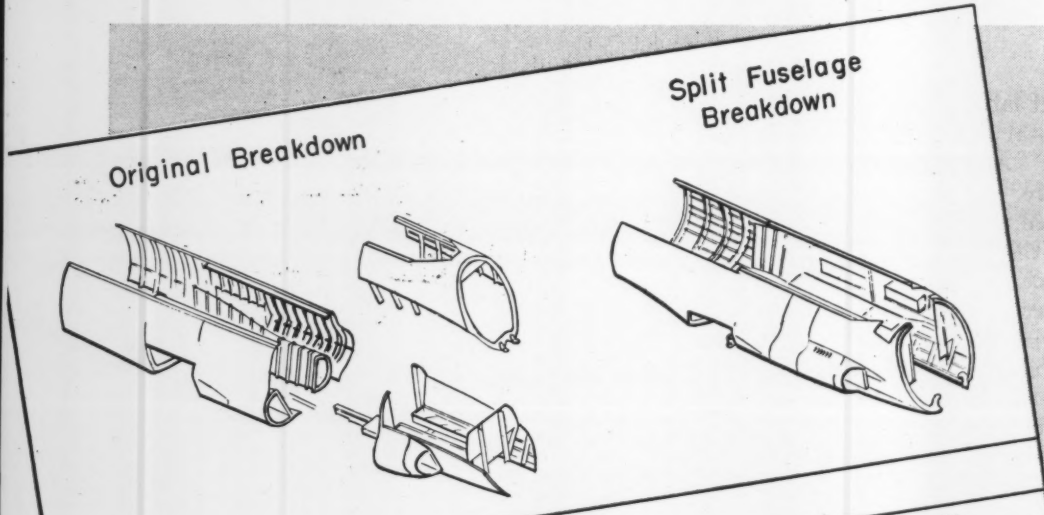
final cost of manufacture. Shape is the first concept which must be analyzed. Straight element lines on large sheet-metal assemblies save fitting and forming problems. Machined elements must be held to a configuration which allows economical machining. Double curvature always leads to complicated parts produced by any method and should be avoided.

Breakdown: Large units such as airplanes, busses, and machine tools must be separated into independent structural components to facilitate their manufacture. Along with shape, the size and extent of these major elements must be considered. They must be sufficiently open to allow assembly access without requiring unusual positions on the part of the workmen. Work is always performed most efficiently when the operators or assemblers are in a natural position.

Attachments for fairings, doors, canopies or any operating units should be kept on individual major elements. Due to the fabrication tolerances on each unit, it is difficult and costly to hold interchangeability where attachments occur across a joint between two major assemblies. If such an attachment is unavoidable, adequate take up in the form of oversize holes, shims, eccentrics, clips, etc., must be provided.

Assemblies should be designed so that they are complete structural and functional units, with testing and operational checks performed on the subassembly where possible. However, excessive breakdown results in increased cost and should be avoided. Components should be as large as handling and processing facilities will allow. The size of major aircraft components, for example, wing sections, is often governed by the length of shipping facilities such as box cars and trucks. *Fig.* 3 indicates how breakdown can affect direct costs. It should be noted that the original breakdown required most cockpit installations after mating of the structure. Working area was limited and cramped, and many installations were performed with the worker lying on his back or side. The improved half shell breakdown allows comfortable working positions at waist level and eliminates the previous congestion of workmen in the cockpit area. This allows a reduction of inventory from 140 units to 76 units in the line. Capital investment is reduced from 81,730 to 63,210 square feet of floor area required for the same rate of production. Tooling and direct assembly costs were also reduced.

Joints between major units should present a single flat plane so that all attachments are produced by simple plane type tooling, which is the easiest to co-ordinate. Attachments should be held to a minimum number to simplify the tooling and as-



Analysis	Original	Split
	140 Positions	76 Positions
Setback of fuselage assembly from completion of forward fuselage to start of major jigs	81,730 sq.ft.	65,210 sq.ft. 40.5 Manhours/ship
Area, direct working area		
Manhour saving due to greater accessibility	15,850 hrs.	8 600 hrs.
Manufacturing aid hours to build major jigs and sidestands	2960 ft.	2 760ft.
Mechanization Length for major lines	12	4 or 5
Transfers of assemblies from one fixture to another		

Fig. 3 — Original trainer fuselage breakdown and simplified split - fuselage breakdown. Note reduction in man hours, inventory and capital investment realized

sembly procedure. The attaching plane should never be canted to the major axis of the assemblies; this complicates the tools and allows errors to creep in which otherwise would not occur. Where major units are to be joined, peripheral attachments must not be used due to the extremely close tolerances required to obtain interchangeability. The basic difference in joints is illustrated by *Fig.* 4. Where feasible, all attachments should be through holes sufficiently oversize to allow for variations in manufacture. Tight fitting fasteners complicate tooling and cause assembly difficulties.

Adequate mismatch should be allowed at all joints. This is well illustrated by the method of fitting fenders and trunk doors on some automobiles. These are provided with intentional steps which allow manufacturing variations without poor appearance. In those cases where exact fairing is required by the design, contour steps produced by manufacturing tolerances cause poor appearance and may impair function.

In order to allow the use of automatic assembly equipment, such as riveters or welders, and to avoid congestion of manpower in a major jig, it is desirable to break major assemblies into smaller components. These may be attached to one another by shear connections since the weight and cost of a large number of tension face type joints is inadvisable. These joints are easily produced because no functional equipment would be installed prior to assembly of the structural components, thus allowing full accessibility. However, joints of this type are not economical for joining major assemblies. *Fig.* 5 illustrates a joint which was originally of the shear type, and was changed to a tension tie with substantial savings. A major factor in the higher assembly time of the riveted joint was its inaccessibility for assembly riveting operations due to equipment and functional installation prior to mating. These could have been installed after mating but only with a tremendous increase in assembly man hours.

Structural Design Considerations: With the basic configuration and breakdown well in mind, the designer can begin to consider the design of the basic structural element. Obviously the type of design will vary with design quantity but certain aims stressing simplicity must be adhered to, if good production design is to result.

Design for minimum assembly operations. Fewer parts mean fewer man hours in both assembly and fabrication. In general, with fewer parts less indirect time is required for issuance of shop orders, production control, stock control, etc. In *Fig.*

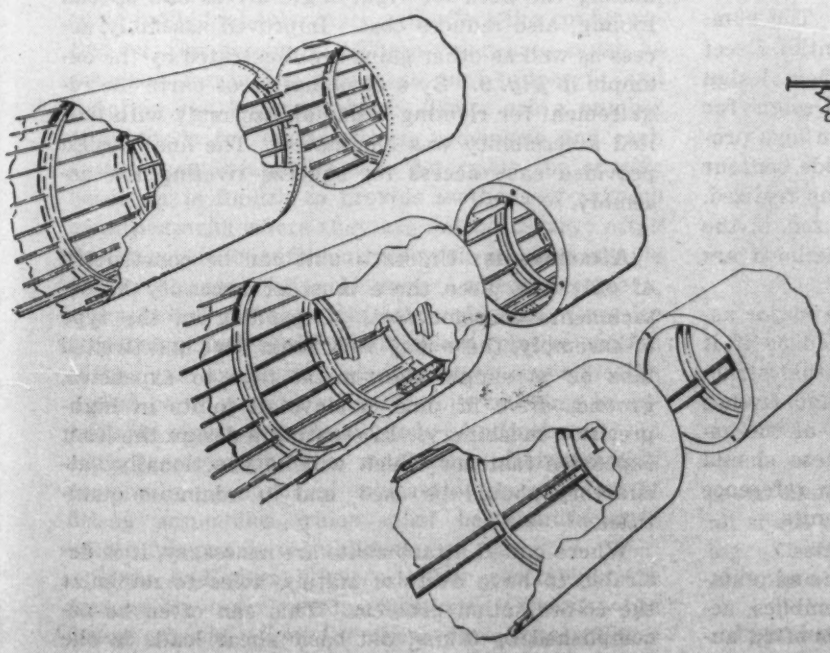


Fig. 4—Peripheral joint attachment (upper left) requires a large number of attachments and a close fit of mating parts. Simplified tension joint (center) reduces assembly time and necessity for close diametral tolerances. Note possibility of structural simplification with concentrated attachments (lower right)

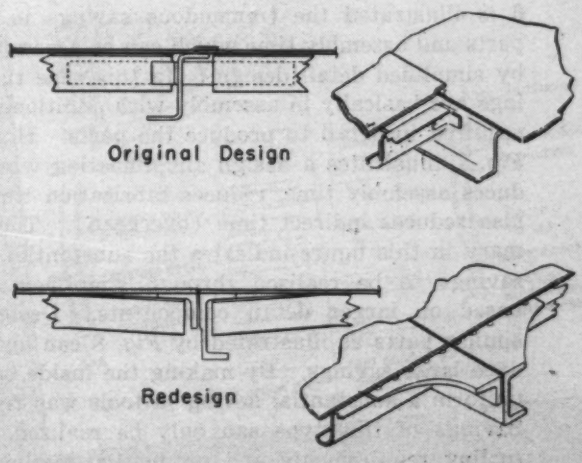
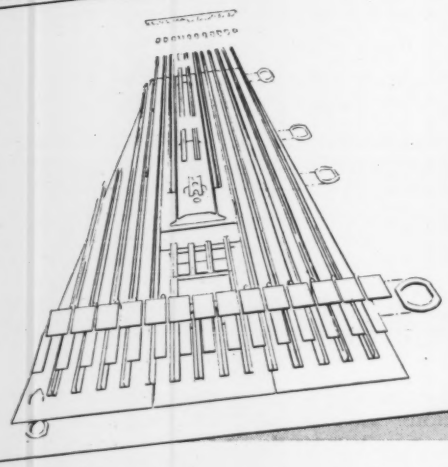


Fig. 5—Above—A typical shear joint which was redesigned to a tension joint with savings of 106 man hours per ship and 1145 square feet of floor space

Comparison Per Airplane — Inner Wing Lower Surface — 1049 Constellation

	Conventional Design 120,000* gross wt.	Integrally Stiffened Design 130,000* gross wt.	Savings	Savings Over Conventional
Total number of detail parts	1,806	334	1,472	81.5%
Total attachments: rivets, screws, bolts, nuts, etc.	41,000	7,224	33,776	82.4%
Weight of sealant (lower portion of wing only)	80*	30*	50*	62.5%
Total weight of structure including all parts & sealant	1736.9*	1442.4*	294.5*	17.0%



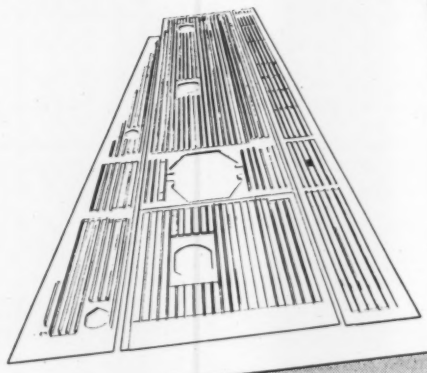


Fig. 6—Savings in assembly man hours by integral design with reduced number of parts is shown by this analysis of the Constellation wing surface

PRODUCIBILITY

6 is illustrated the tremendous savings in detail parts and assembly time which can be accomplished by simplified detail design.[3] In this case the savings are basically in assembly with additional time required in detail to produce the parts. However, *Fig.* 7 illustrates a design simplification which reduces assembly time, reduces fabrication time and also reduces indirect time (overhead). The summary in this figure indicates the substantial direct savings to be realized through simplified design based on larger detail components. Design for similar parts as illustrated by *Fig.* 8 can also produce large savings. By making the inside contour uniform a substantial saving in tools was realized. Savings of this type can only be realized if the tooling requirements and production methods are constantly kept in mind.

With the exception of the joints, each major assembly and detail part must be designed as if it were a free body in space. This means that structural portions such as ribs, stiffeners and frames should be located to the best advantage of the assembly and fabrication operations. These should be located without regard to arbitrary reference lines or structural elements in adjacent units.

Accessibility: With the combination and elimination of parts to produce simpler assemblies, accessibility for assembly and fabrication is often automatically provided. However, this factor must always be carefully considered because poor accessibility causes delay and increases cost. Formed parts should be provided with punch and die accessibility. Back draft would require expensive tooling with cross slides or subsequent hand forming. Access for automatic riveting equipment allows more rapid assembly of sheet-metal components. Access for adequate cutters in machining operations and allowance for side, face and slab mill cutters where feasible reduces machining cost. Providing adequate space for drills and fixtures, thus eliminating the need for right-angle drives and special tooling, also reduces cost. Improved assembly access as well as other gains are illustrated by the example in *Fig.* 9. By a combination of parts the requirement for riveting inside an assembly with limited accessibility was eliminated. The final design provided easy access for squeeze riveting the assembly.

Attachments: Unless a unit can be constructed of only one piece there must of necessity be attachments of some sort. Depending on the type of assembly, these may vary from bent and twisted tabs as in simple sheet-metal toys to expensive, ground, drive fit pins or dovetail joints in high-precision machinery. In creating a design the least expensive fastener which will be functionally satisfactory should be used, and in minimum quantities.

Where bolted attachments are necessary, it is desirable to have oversize mating holes to minimize the co-ordination problem. This can often be accomplished by taking out basic shear loads in one snug fitting fastener and allowing looseness in others. To minimize attachment time, high-production methods such as metal stitching, automatic

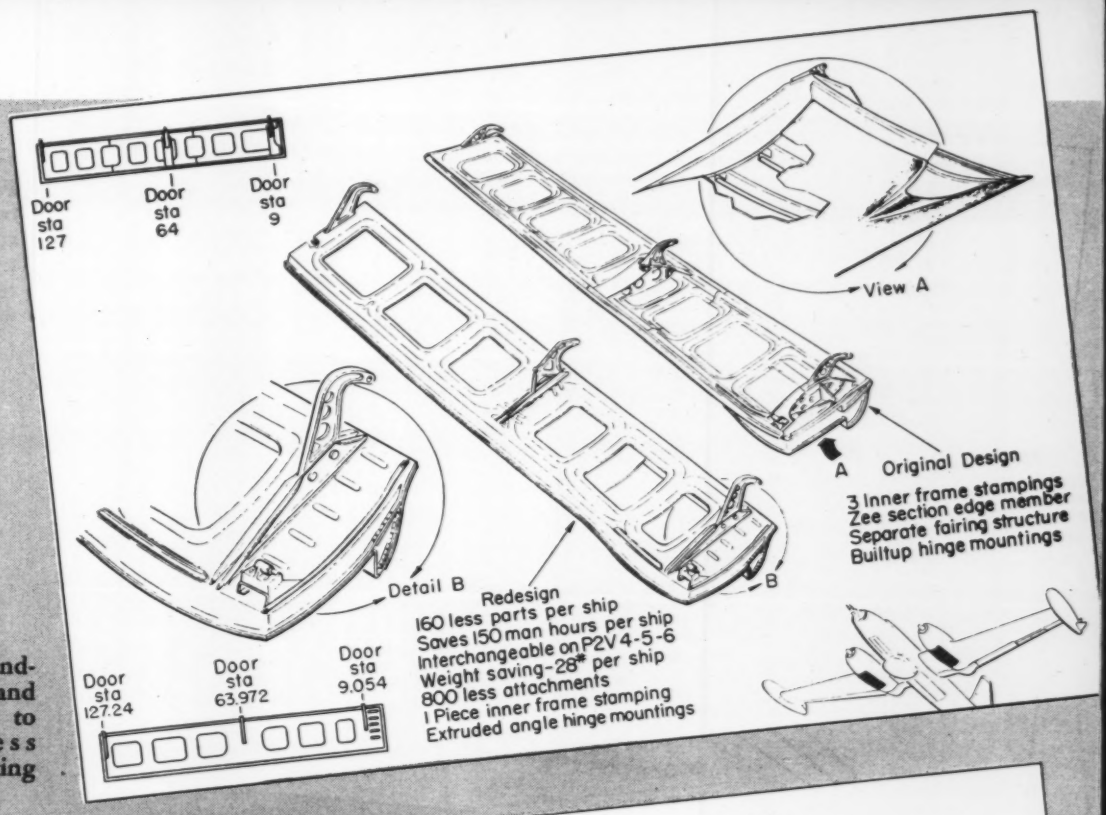


Fig. 7—Original landing gear door, and door redesigned to utilize large press forming, eliminating bits and pieces

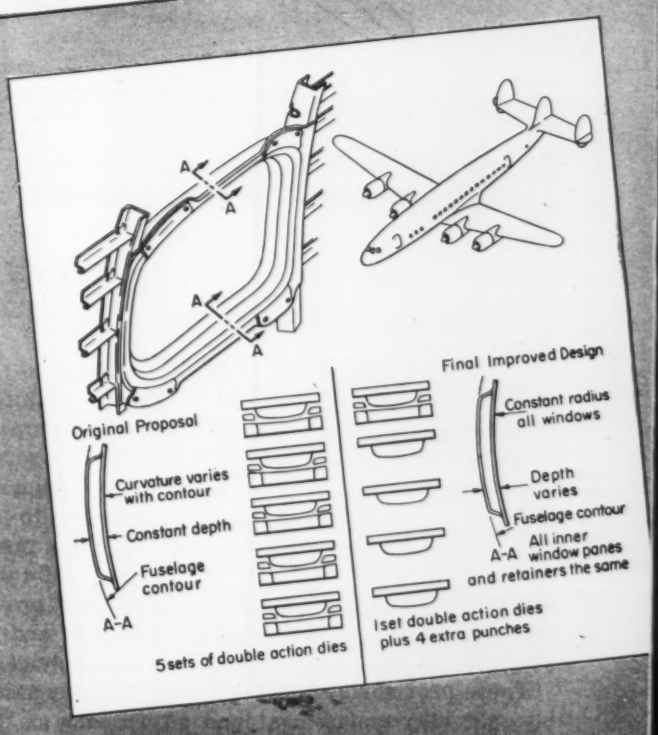


Fig. 8—Design study of cabin window illustrates how minor modification to theoretical inside contour reduced tooling required

riveting and spotwelding should be incorporated. A promising new development in aircraft has been the use of metal-to-metal adhesives. While not used extensively in other industries as yet, these materials and methods reduce the number of attachments and, therefore, give promise of reducing assembly time and costs.

Alignment and Fit: Whenever a series of details and subassemblies must be combined into one unit, their individual tolerances will affect the configuration of the assembly. These tolerances must be provided for in the design so that proper fit and function can be maintained. There are a number of methods for making these provisions and each design must be analyzed to determine the specific need. It is foolish to provide methods of take-up or adjustment where they are not necessary; often the structure is sufficiently flexible to allow simple pull-in on assembly. However, where necessary, a number of methods can be considered. Oversize attachment holes which will allow relative motion of the two parts can be used most economically. Added parts such as separate clips or shims or adjustable struts provide methods of adjustment. In some cases trimming or machining after assembly provides an economical solution of the problem of fitting assemblies which must be manufactured within reasonable detail limits.

Steps and gaps between major assemblies are permissible under certain conditions. Obviously the design should allow for these variations. These allowances eliminate hand work and blending. Where the prints do not specifically allow these variations and they occur, the resultant rejections cause unnecessary rework. It is the tendency of all shops to spend excessive time fitting and blending. Costs are materially reduced when these operations are no longer necessary.

Functional Design Considerations: It is too often the design attitude that once the basic structural element is properly designed, functional items are then easily installed. This method of design, while

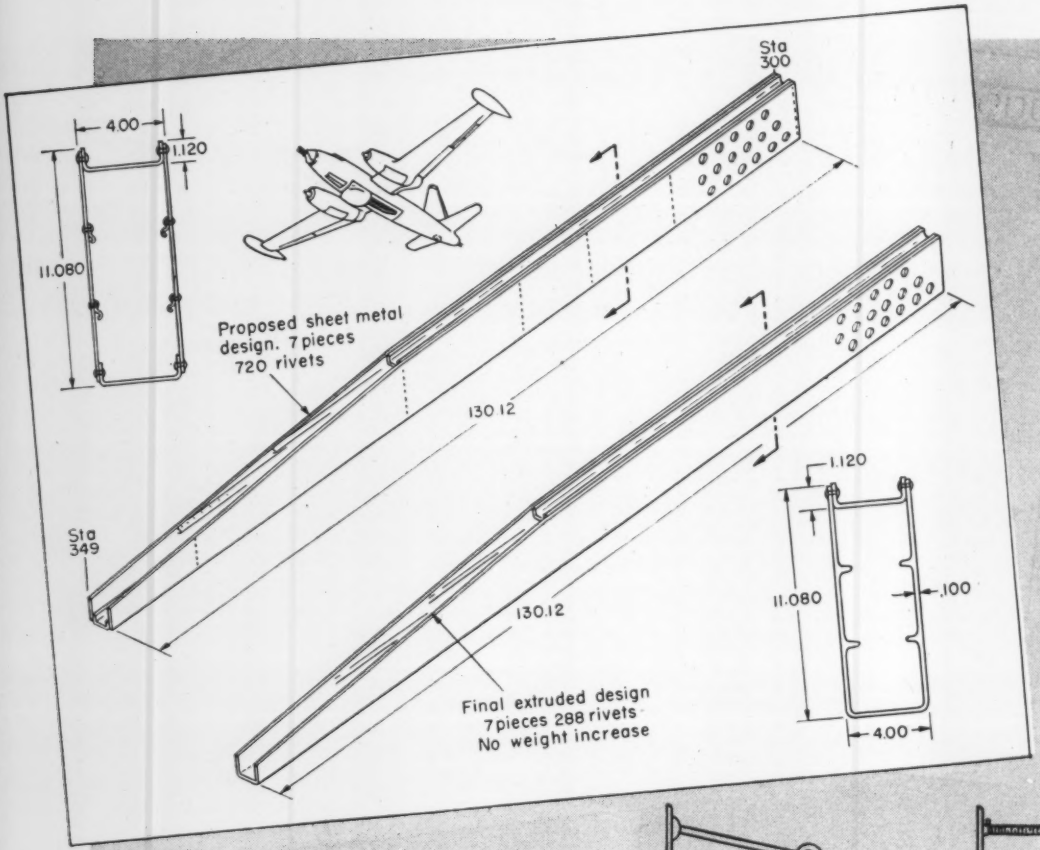


Fig. 9 — Proposed beam and final extruded design illustrate improved assembly access and reduction in parts and attachments

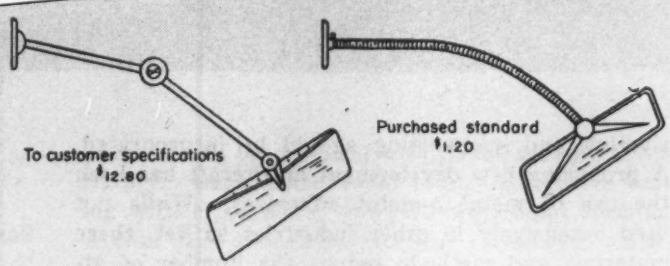


Fig. 10—Comparison between sun shades indicates how customer specifications can be modified to reduce costs

in prevalent use, causes a great deal of lost time and difficulty in assembly. Sufficient consideration must be given the method of installing and servicing the electrical, hydraulic, control, and equipment units so that the basic structure is designed to provide for their economical installation. This means providing external tunnels for long runs of tubes, wires, or control cables where feasible and providing accessibility in details, subassemblies and assemblies for the installation of functional items.

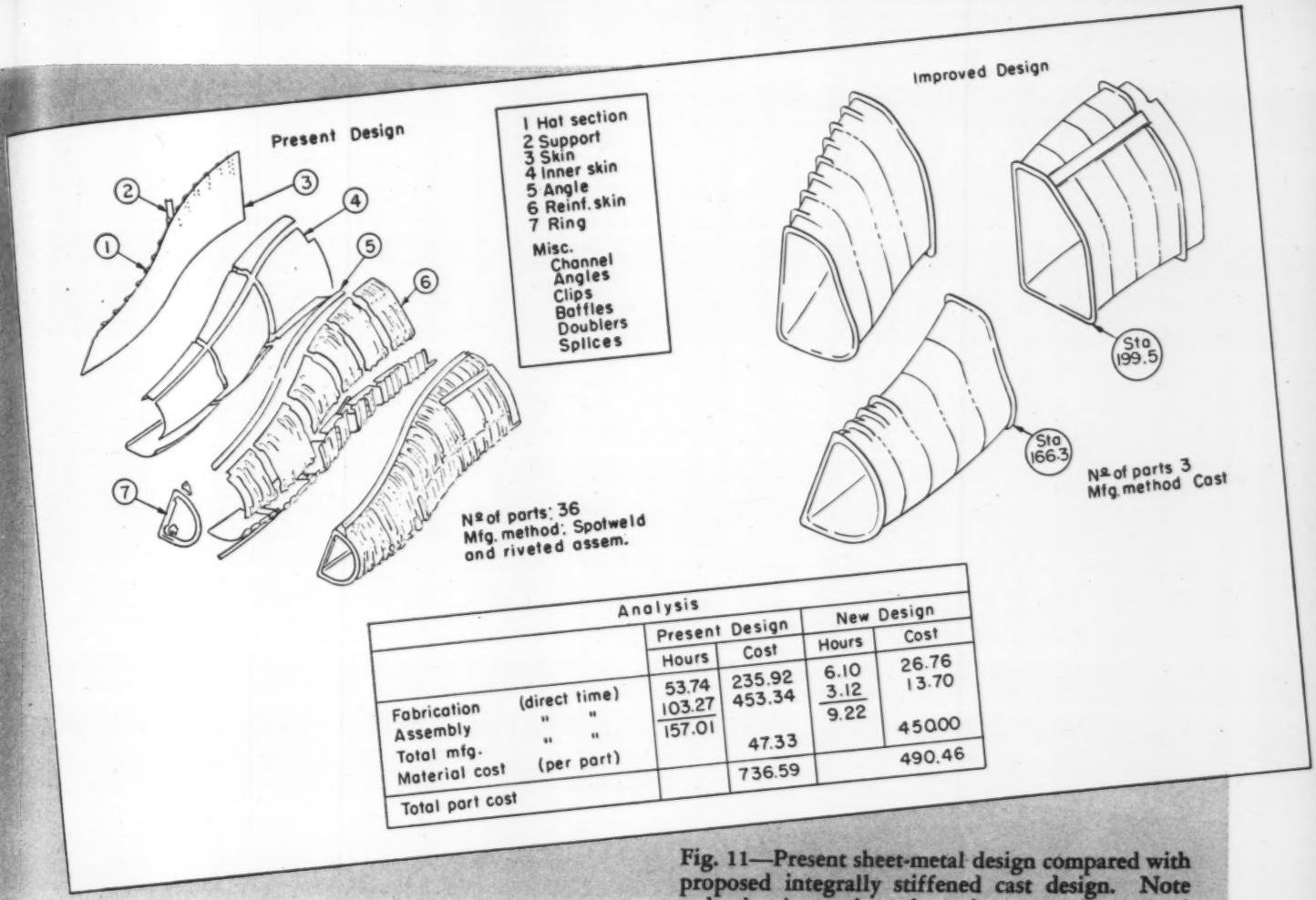
These provisions should not only consider assembly, but also replacement and adjustment as they are all important to the producibility and serviceability of any item. Before actual delivery, many control, electrical, and hydraulic equipment items will need adjustment and possible replacement. This includes such things as electrical window actuators in airplanes, heating systems in busses and airplanes, radios, radar units, etc.

The foregoing structural design principles must also be kept in mind when designing functional equipment and installations. Simplicity of, and accessibility for, fabrication, assembly and installation are important. Minimum numbers and types of attachments should be used. A basic consideration in the design of functional items, however, is the alignment problem. Whenever hinge points, for instance, must align they should be installed on one major structure. Where this is not possible, then adequate adjustment must be provided. The use of self-aligning bearings can eliminate misalignment problems. This in turn will save many man hours due to the elimination of assembly shimming operations and will minimize malfunction and service difficulties due to the manufacturing misalignments. By the same token, in push-pull and torsional systems, adequate adjustment and flexibility must be provided to allow for tolerances in support structure location. The universal joint is a typical example of this type of take-up.

Mechanical systems and mechanisms should be designed for mechanical simplicity. Where a mechanism is mechanically simple and easily understandable, few shop, planning and engineering errors will occur.

It is axiomatic, that personnel work more efficiently at a bench than in a crowded assembly area. Obviously then, functional items must be designed for large bench assembled units which may be completely checked out prior to installation. Wire harnesses, hydraulic tubes and their related equipment can only be thus assembled and checked when sufficient room for their subsequent installation is allowed in the structural design.

Challenge Basic Criteria: Keeping the principles



Analysis		Present Design		New Design	
		Hours	Cost	Hours	Cost
Fabrication	(direct time)	53.74	235.92	6.10	26.76
Assembly	" "	103.27	453.34	3.12	13.70
Total mfg.	" "	157.01		9.22	
Material cost	(per part)		47.33		450.00
Total part cost			736.59		490.46

Fig. 11—Present sheet-metal design compared with proposed integrally stiffened cast design. Note reduction in number of attachments and improved joints

outlined in mind, the designer must always consider and challenge the basic design criteria in his approach to production design. Too often data are obtained from another source within a company and used, without question or analysis, to the detriment of the product. This includes such information as loads, thermodynamic requirements, aerodynamic requirements, shape, customer requirements, previous assumptions, and many others.

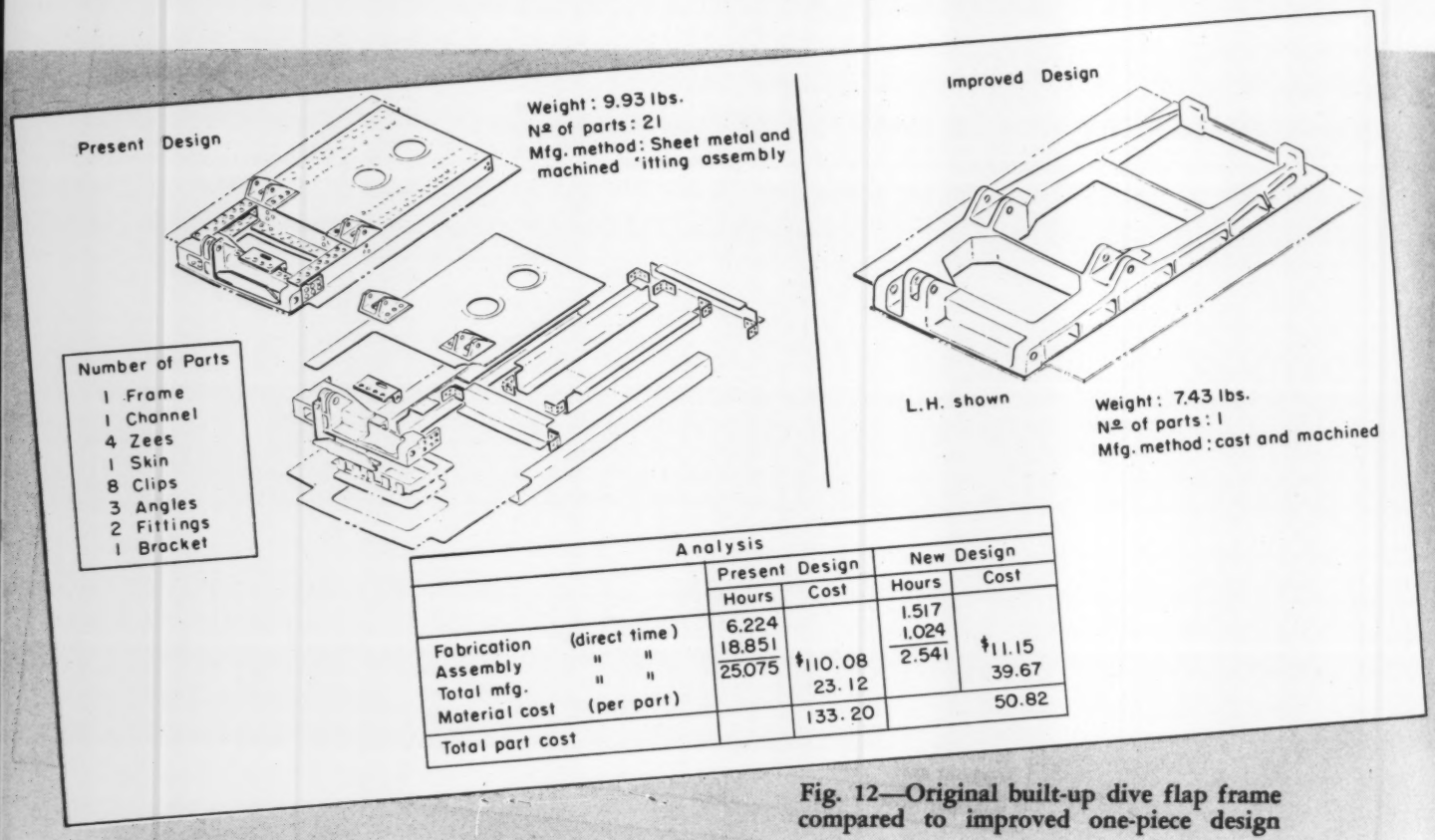
During the early stages of any design, necessity must be questioned. If a piece of equipment, bracket, structural member, or functional installation can be eliminated, a large cost reduction is immediately realized. Often redundant items of this type are carried in the design because a careful analysis of the actual requirements was not made. One method of eliminating major units is by combining functions. However, it is sometimes necessary to have duplicate systems so that malfunctions will not cause loss of an aircraft or loss of life. Even in a situation of this type it is possible to save duplication. As an example, in a certain aircraft, duplicate hydraulic elevator boosters are required for safety. However, instead of installing a complete duplicate, both systems were designed into a single frame. Malfunction of one will not affect the other, and duplicate mounts would be both more expensive and heavier.

PRODUCIBILITY

A common pitfall in any design is the use of duplicate safety devices. In some cases as many as two to three warning units may be utilized to police the functional system. These extra safeties are expensive and do not really solve the basic problem. Usually a redesign of the malfunctioning system and elimination of duplicate items results in a cheaper, safer, and more trouble-free job.

There are many illustrations which show how a challenge to the basic criteria can reduce costs. *Fig.* 10 illustrates only one phase. Assume the customer specified a sunshade articulated in three joints to allow universal position. An item of this sort could be readily designed with approximate costs as indicated. On the other hand, a designer finds a standard purchased item. This unit fits the function but not the letter of the customer's specifications and is substantially cheaper. By presenting the problem to the customer a specification revision allowing the use of the standard unit can generally be obtained.

Analyze Overall Configuration: After a designer has satisfied himself that the basic design criteria he is using are complete and adequate, and with



Analysis		Present Design		New Design	
		Hours	Cost	Hours	Cost
Fabrication	(direct time)	6.224		1.517	
Assembly	" "	18.851		1.024	
Total mfg.	" "	25.075	$110.08	2.541	$11.15
Material cost	(per part)		23.12		39.67
Total part cost			133.20		50.82

Fig. 12—Original built-up dive flap frame compared to improved one-piece design

PRODUCIBILITY

no redundancies, he must analyze the overall configuration of the design. Mating problems, the effect of related assemblies, fits, attachments, shape, must be considered. These items will have a direct influence on the final design and if ignored an uneconomical design with possible assembly interferences and limited access will always result. The basic production design principles outlined must be ever in mind if the analysis is to yield maximum results.

In conjunction with the configuration analysis must come the determination of basic design type. Several studies may be required to make a final decision. Functional and structural considerations may sometimes dictate a design, but production considerations usually have a major effect. A structure for a machine tool, for instance, may be cast, forged, or welded. The choice of design is basically a production consideration, although strength and weight may also be factors. An airplane structure may be conventional, built from a myriad of bits and pieces, or it may be of integral stiffened design. If integrally stiffened design is chosen (when applicable this method almost invariably presents substantial savings), it can be cast, *Fig.* 11, machined from plate, *Fig.* 6, or forged. As illustrated by *Fig.* 11, the method chosen has a basic effect on the number and type of joints, their fit and attachments. The sheet-metal design consists of many details combined into several assemblies which are joined by multiple riveting operations. The simpler integrally stiffened cast design is only three pieces with simple, single-plane joints requiring only a few fasteners.

Analyze Detail Design: Once the general configuration and basic design type have been determined, the design emphasis must be on a clean detail design. However, the basics must always be kept in mind. Should the detail design become complex due to earlier decisions, then the basic concepts must be re-examined to determine whether further modifications would serve to simplify the product.

Concentrated effort should be expended in reducing the number of parts in any assembly. In general, the part which can be made from one piece rather than several will be less costly because each detail requires its setup, fabrication, numbering and finishing operations, followed by an assembly job. A one piece part requires only one shop order as against many for the multipiece assembly.

The savings which can be realized by combining parts are substantial, *Figs.* 12 and 13. Both illustrations are used to show that different methods of approach yield equally good results. *Fig.* 12 changed from a sheet-metal design to a casting while the parts illustrated in *Fig.* 13 are merely a refinement of the sheet-metal design to eliminate the bits and pieces and their assembly. It is to be noted that both analyses include only direct time. It has been estimated that the cost of paper work

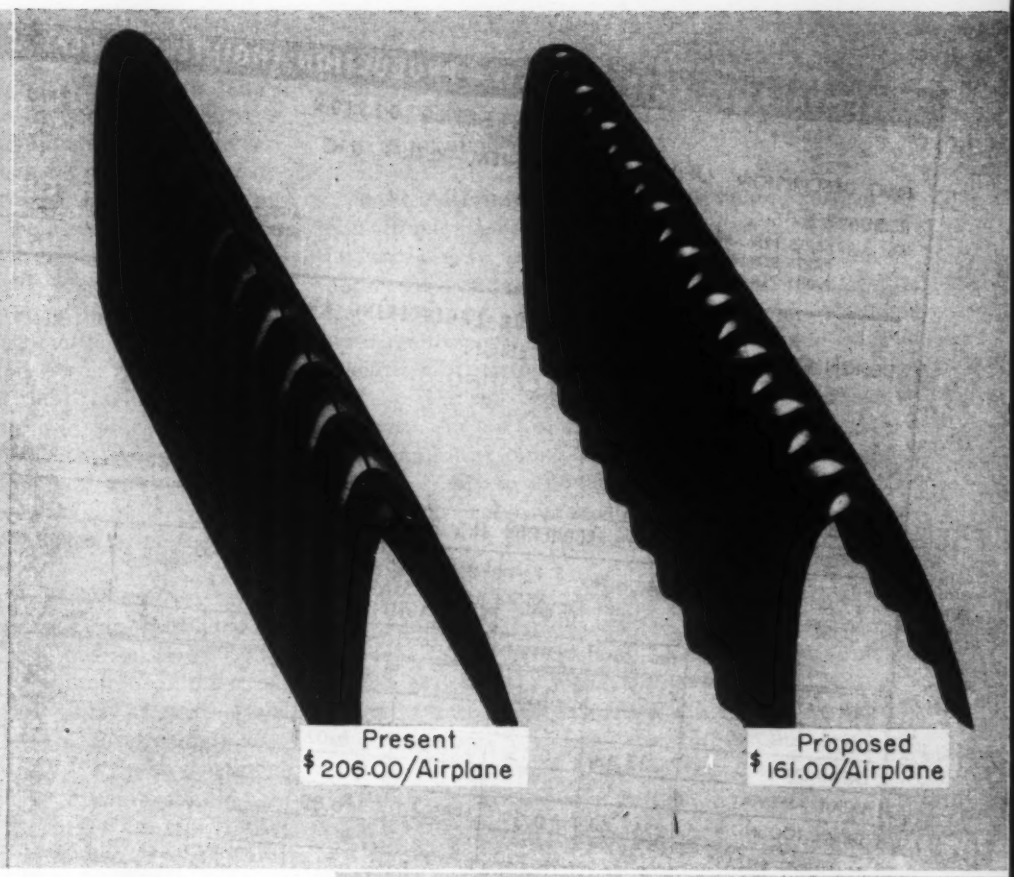


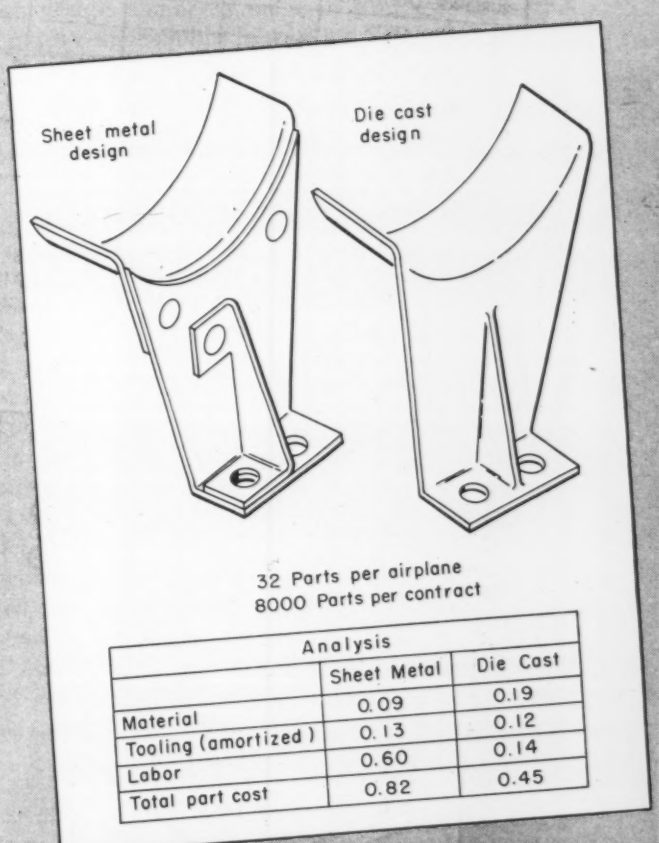
Fig. 13—Leading edge corrugation design improvement. Note elimination of splice plates and attachments

for a lot release per part number for fabrication operations in a large organization can be as high as $25.00. Thus it would cost $500.00 more for each lot release of the multipiece design shown in *Fig.* 12 than for the cast design.

Substantial savings can also be realized by multiple usage of identical parts. Where several parts nearly the same are required, special effort must be expended to make them identical. This results in savings two ways: First, indirect labor is reduced and, second, it is often possible to go to a higher production method, thereby making even greater savings, *Fig.* 14.

How to make the detail components must now be considered. There are usually several acceptable methods for producing any part. A sheet-metal rib can be made by stamping or hydropress. A machined part can be made by using bar stock, a forging or casting. Often a sheet-metal component built-up of several details can be converted to a more economical casting, *Fig.* 15, forging or other machined part. One of the potentials commonly overlooked in detail design is that of extrusion. Where a uniform, extrudable cross-section can be used, this method of fabrication is often more economical than forgings, castings, or bar stock, subsequently machined. How the material choice can affect costs is illustrated in *Fig.* 16.

The cost analysis, *Fig.* 15, is a handy and necessary tool in determining the direction which must be taken by the design.[4] At Lockheed there is close teamwork among designers, production de-



Analysis		
	Sheet Metal	Die Cast
Material	0.09	0.19
Tooling (amortized)	0.13	0.12
Labor	0.60	0.14
Total part cost	0.82	0.45

Fig. 14—Multiple-usage part allows utilization of high-production die casting in place of sheet-metal fabrication

COMPARATIVE COST ANALYSIS — PRODUCTION ENGINEERING DEPT.

ENGINEERING DESIGN

PART DESCRIPTION: LINK-FLAP MECHANISM - RETRACTING

DRAWING NO. 3110 2780
MODEL A

REQUIREMENTS:
PARTS PER AIRPLANE 20
PARTS PER LOT RELEASE 300
PARTS PER CONTRACT 6000

AIRPLANES PER LOT RELEASE 15
AIRPLANES PER CONTRACT 300

PRODUCTION ENGINEERING ANALYSIS

DESIGN STUDY: # 1 SHEET METAL DESIGN
2 INVESTMENT CASTING

REQUESTED BY W.A. RIDING

PRODUCTION AND ENGINEERING EVALUATION

COST FACTOR	DESIGN NO. # 1 SHEET METAL		DESIGN NO. # 2 INVESTMENT CASTING		DESIGN NO.		DESIGN NO.	
	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST
RAW MATERIAL	$	$ 0.05	$	$ 0.26	$	$	$	$
LABOR—RUN TIME		3.15		0.02				
LABOR SET UP	37.68	0.13	5.37					
LABOR ASSEMBLY								
DETAIL TOOLING	2367.40	0.39	1800.60	0.30				
PLANNING RELEASE								
ENGINEERING RELEASE				1.90				
PURCHASE QUOTATION								
O. P. QUOTATION								
COMPARATIVE COST — TOTAL	$	$ 3.72	$	$ 2.48	$	$	$	$

CONCLUSION: From the above analysis, Design #2, Investment Castings, is $1.24 less than Design #1. Total savings over the contract quantity is $7,440.00.

In Design #1, Sheet Metal Construction, there are four detail parts per link and the weight is .054#. In Design #2, Investment Castings, there is one part per link which weighs .034#. The weight savings per aircraft is .4#.

APPROVED R. H. LUDERS

COST ANALYST HERMAN B. BARISH

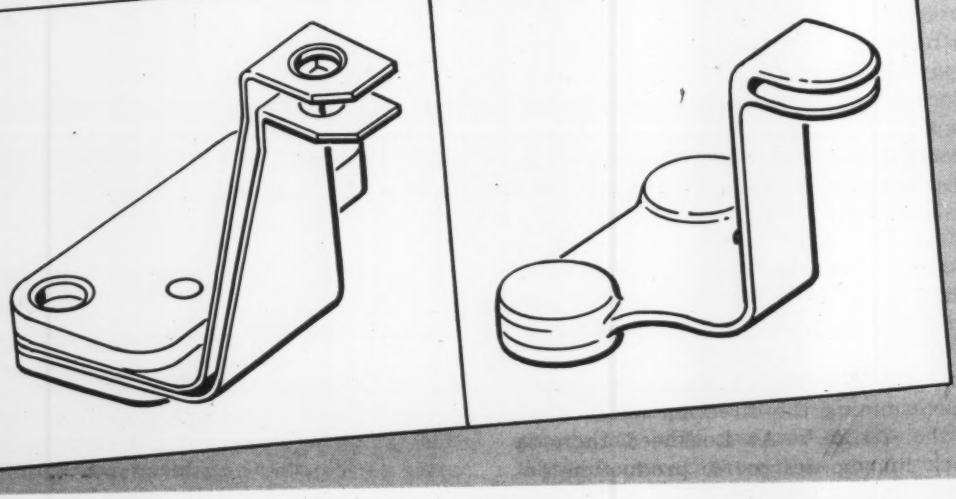


Fig. 15—Cost analysis indicates substantial savings which can be realized by the use of alternate fabrication methods

signers and cost analysts, so that the most economical general and detail design for the quantities to be built can be evolved.

Even with the basic and detail design types determined, further concentration on design details pays off handsomely. Sheet-metal or machined parts are always cheaper when they can be manufactured by fewer operations. Tolerances must be as large as the function will permit. Tight machining tolerances must not be applied to sheet-metal components since this would require machining on parts otherwise fabricated in the sheet-metal shop.

Problems encountered in the actual fabrication of parts must be considered and notes covering these conditions should appear on the drawing. This includes allowance for spring and warpage where large amounts of raw material are being removed from machined parts. It includes waviness tolerances, permissible warpage, maximum permissible machined surface finishes, alternate methods of fabrication and many others.

Machined parts should be carefully analyzed with special attention to each machine cut. Methods of clamping and cutting should be known so that the parts can be designed for the minimum number of setups and the most economical types of cuts. End milling is to be avoided since accuracy and cost are both affected detrimentally. Where forgings and castings are used, every attempt should be made to use "as cast" and "as forged" surfaces. It must be remembered that aluminum forgings are sufficiently smooth to allow fastening to "as forged" surfaces without machining.

There are a myriad of small items which help to make detail design clean. Space prohibits covering more than just the few mentioned; however, if the designer remembers the production problems of detail manufacture, a clean easy-to-build detail part can be created.

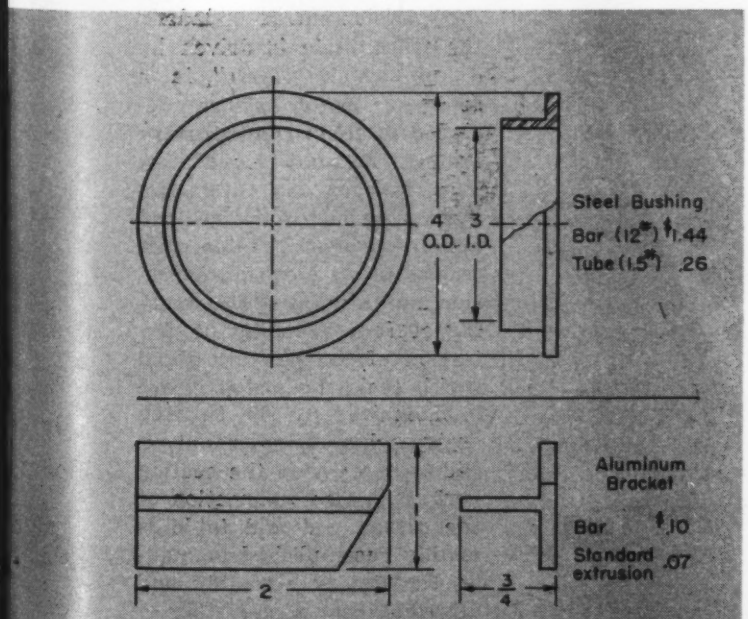


Fig. 16—Comparison of materials shows how their choice can influence the ultimate product cost

Make Alternate Studies: As indicated by the design illustrations shown, alternate studies must be undertaken to properly evaluate a production design. In the case of simple parts such as *Fig.* 1, these may be accomplished on a scrap of paper with results sufficiently accurate to provide reliable design information. On the other hand a problem such as the one posed in *Fig.* 3 requires extensive studies. As part of the design plan, sufficient time and manpower must be scheduled to perform these studies. Only in this manner will the most efficient production design be realized. However, in all studies made, the basic principles as outlined above must be followed.

Many parts have been simplified by redesign in every industry. However, it is always more economical to do the alternate design prior to having tooled and built a more costly product. In many cases, if the redesign comes after large quantities of the original have been manufactured, it does not pay to re-tool since a net saving on the quantity left to be built will never result.

Approach to Production Design: To guarantee that the basic production design principles are followed, Lockheed uses a specialized group of production design engineers on each project. It is this group's responsibility in working with the designers to obtain the most economical design to fit function, strength and airworthiness. As well as being competent designers, these men are also required to be competent production engineers and to know equipment and procurement limitations so that clean design within the limitations of available facilities will be realized. A further responsibility is the coordination of new material, process and equipment limitations with the manufacturing organization. Obviously the functions outlined must be carried by the designer himself when an engineering organization is relatively small. It is, however, most efficiently handled in a large engineering organization by a special group of production design engineers.

Design for simplicity and attention to good production design principles always results in reduced costs. Provided function is carefully considered, it also results in improved serviceability and simpler operation. These factors all contribute to an improved competitive position for the product and the company and a guarantee that a reasonable profit can be realized on capital investment.

REFERENCES

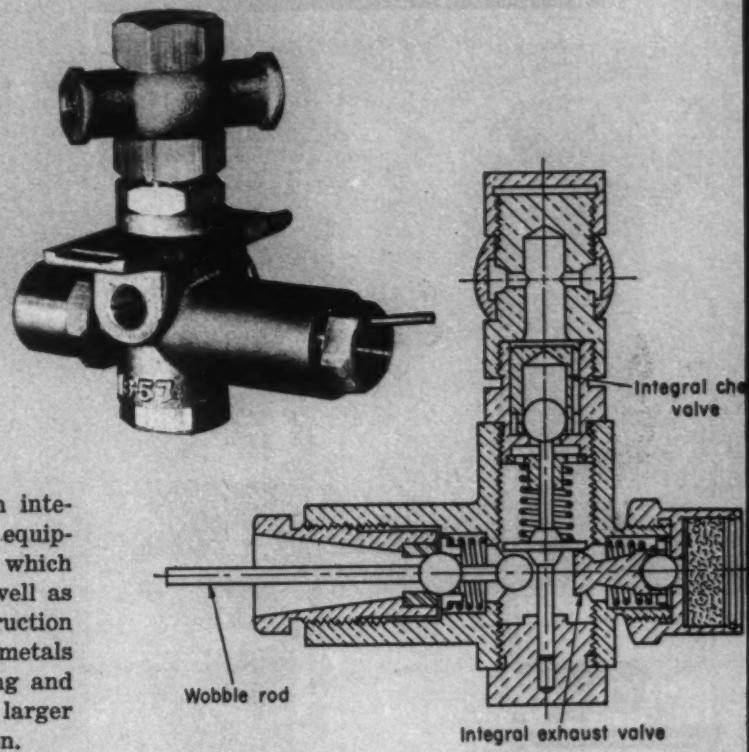
1. W. R. Jones and H. M. Harrison—"Design Producibility Serves the Industry," *Aero Digest*, August 1948.
2. G. W. Papen—"The Designer and Manufacturing Costs," presented at SAE National Aeronautical Meeting, Los Angeles, October 2-4, 1947.
3. G. W. Papen—"Requirements for Large, Light, Metal Forgings and Extrusions," *Aeronautical Engineering Review*, Vol. 12, No. 1, January 1953, page 24.
4. Richard H. Luders—"Engineering Cost Analysis," MACHINE DESIGN, Vol. 24, No. 7, July 1952, Page 145.

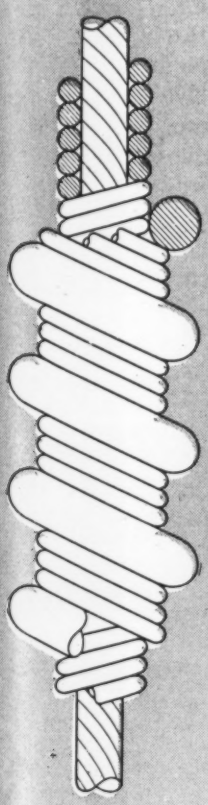
SCANNING the field for IDEAS

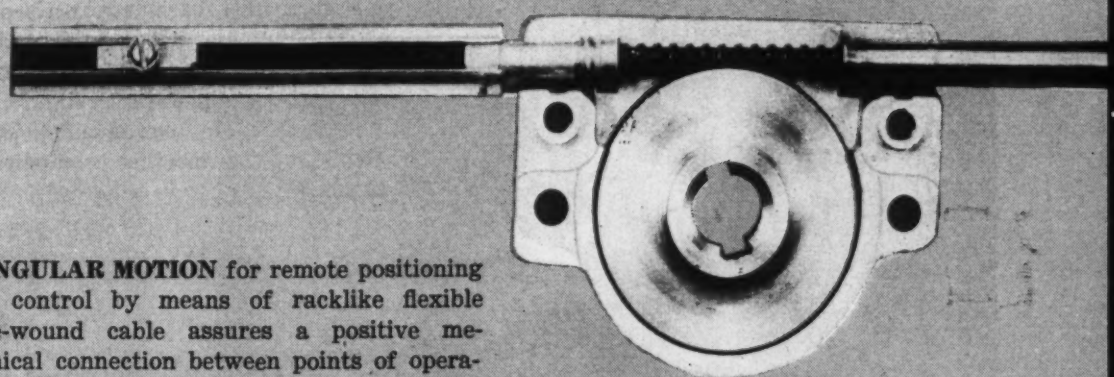
FLOATING PISTON RODS facilitate power connections in hydraulic cylinder drives and eliminate troublesome effects of temperature changes and cylinder misalignment. In a design developed by DoAll Co. for precision surface grinders, the work table is driven by a rod which "floats" in a separate piston sleeve designed to effect the necessary sealing. Angularity and pressure changes are automatically compensated by free rod action, preventing table shift and assuring precision operation and position of the working surface. Binding or distortion of the packing gland which seals the piston sleeve is minimized by the floating design which imparts only a sliding motion at the sealing surfaces. Also, connection of the piston rod and table is readily accomplished manually, facilitating assembly and affording easy accessibility to the working parts for service adjustments or maintenance.

WOBBLE-ROD CONTROL of air flow offers unusual pneumatic circuit possibilities. Developed by Pantex Mfg. Co. for operation at pressures up to 125 psi, a new air valve is designed to be actuated through a hardened lever-rod mounted to swivel freely in a circular opening. Flexibility in both mounting and application are provided by the design which permits lateral play during a vertical throw and can be adapted to a wide variety of actuating motions, either powered or manual.

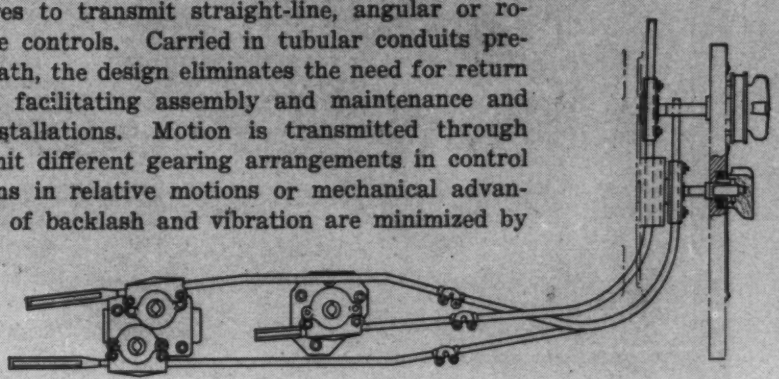
When the free end of the rod is depressed to the lowest position, a ball on the inner end raises a valve stem which unseats a ball check and opens the valve. Release of the rod permits the stem to drop to its normal position, closing the valve and simultaneously opening an integral exhaust valve. Backsurge from attached equipment is prevented by an integral check valve which closes the inlet port. Gaskets and packings as well as bolts and flanges are eliminated in the construction which utilizes a threaded assembly. Dissimilar metals are employed at friction points, preventing galling and reducing operating forces. Suitable as a pilot for larger controls, the valve can be operated in any position.

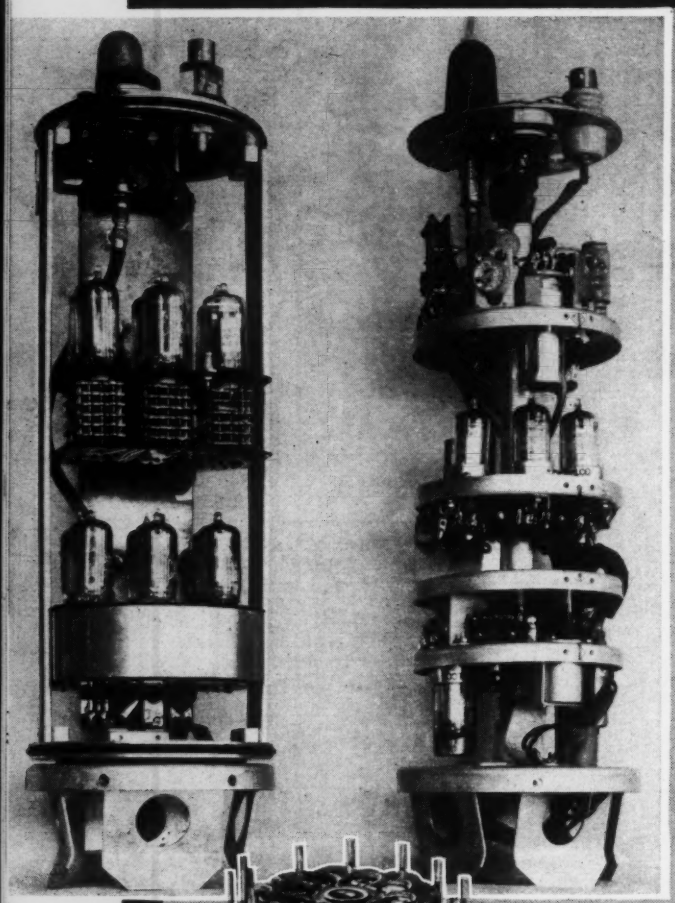


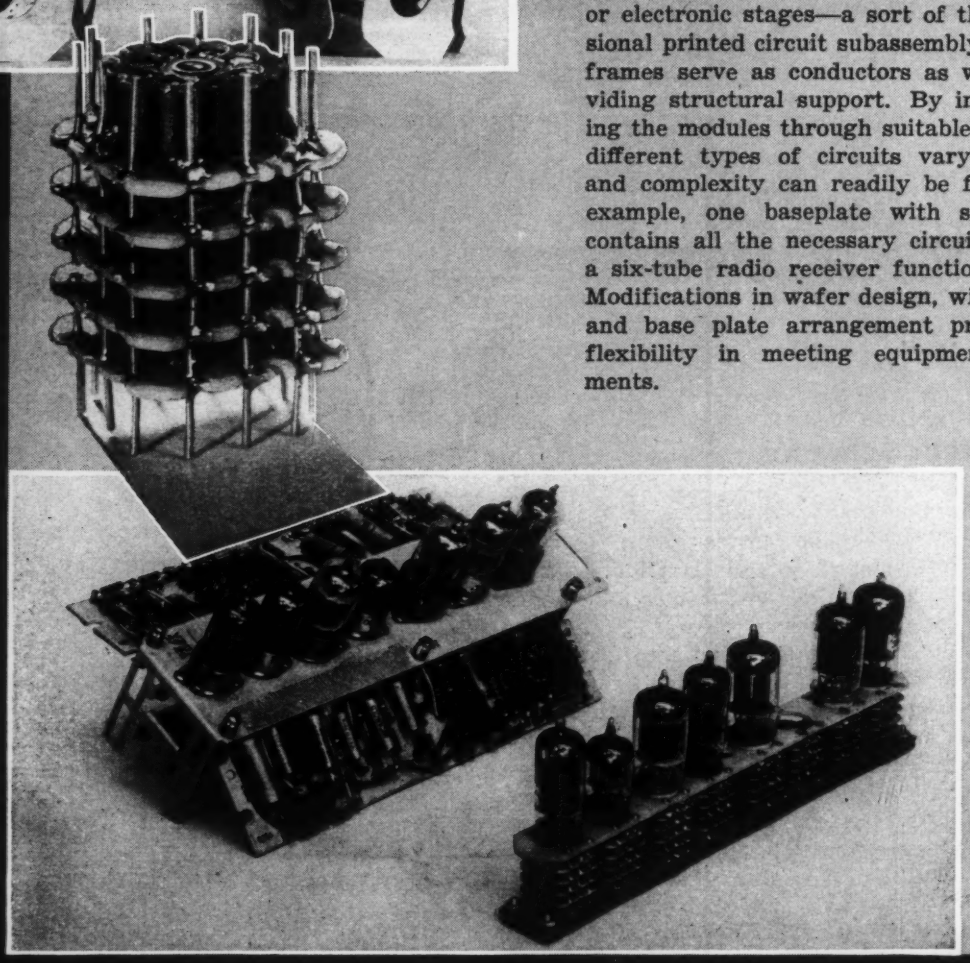




ANGULAR MOTION for remote positioning and control by means of racklike flexible wire-wound cable assures a positive mechanical connection between points of operation. Developed by Teleflex Inc., a novel cable design utilizes an outer helical winding consisting of a heavy wire and three fine spacer wires to transmit straight-line, angular or rotary motion to inaccessible controls. Carried in tubular conduits preformed to fit the control path, the design eliminates the need for return lines and close alignment, facilitating assembly and maintenance and simplifying panelboard installations. Motion is transmitted through hobbed wheels which permit different gearing arrangements in control boxes to produce variations in relative motions or mechanical advantage. Troublesome effects of backlash and vibration are minimized by the cable construction.





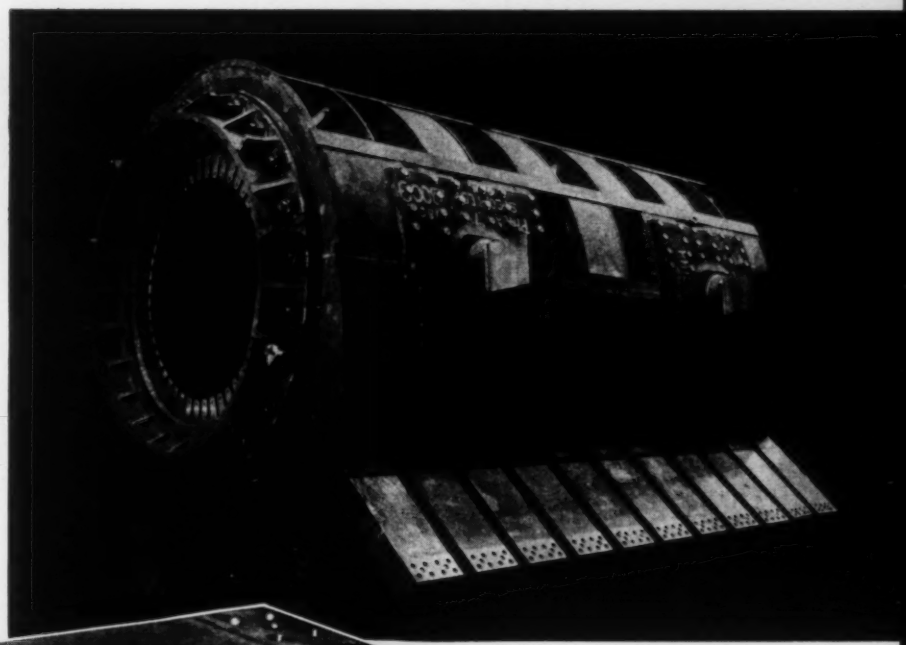


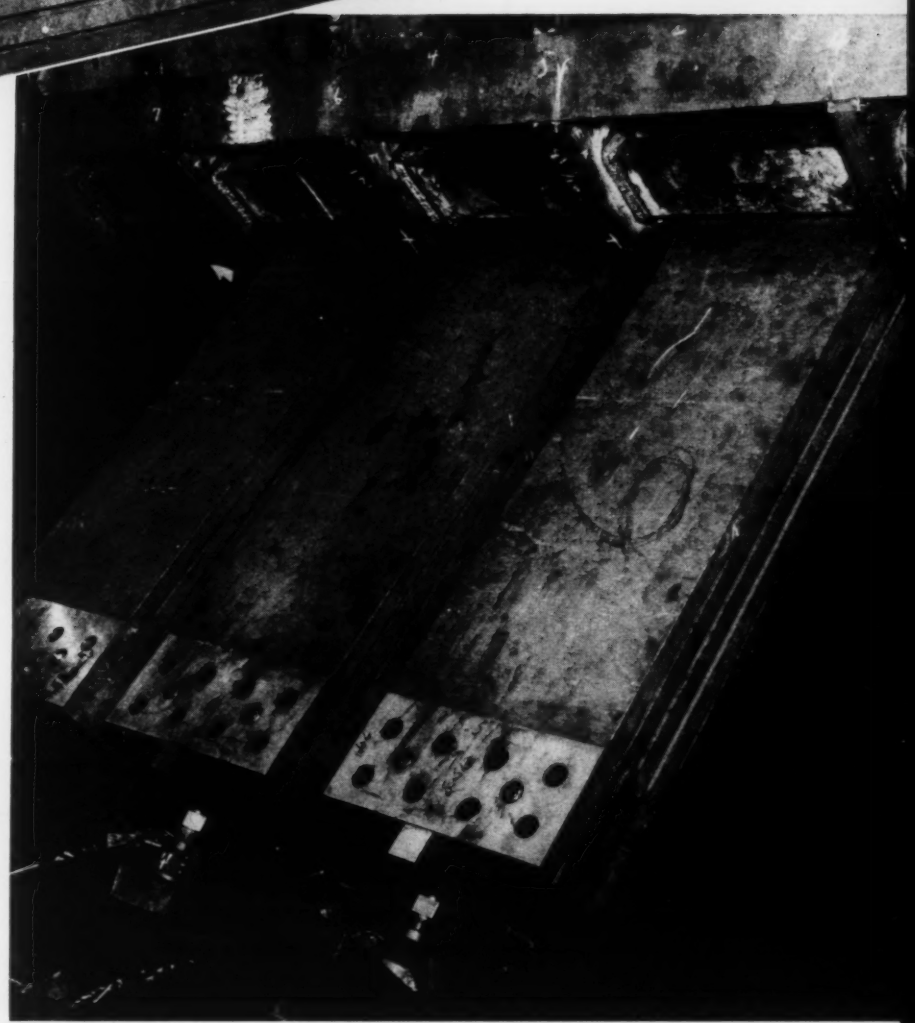
MODULAR DESIGN of electronic circuits provides a neat and compact construction for complicated units and eliminates the need for conventional time-consuming manual assembly techniques. Substantially increased producibility has been achieved through a revolutionary approach to circuit design which utilizes conductive coatings, thin ceramic capacitors, adhesive tape resistors and dip soldering to replace the more bulky conventional components and facilitate automatic processing. In addition, circuit reliability and ruggedness are increased by a sturdy foolproof construction and maintenance is simplified by a replaceable unit design.

Basic element of the system developed by the National Bureau of Standards for the Navy Project Tinkertoy is a thin ceramic wafer (7/8-inch square and 1/16-inch thick), notched on each side, which carries the different miniaturized components on each face. Stacked in predetermined arrangements in wire frames and soldered, the wafers are interlocked to form standardized "modules" or electronic stages—a sort of three dimensional printed circuit subassembly. The wire frames serve as conductors as well as providing structural support. By interconnecting the modules through suitable baseplates, different types of circuits varying in size and complexity can readily be formed. For example, one baseplate with six modules contains all the necessary circuits to make a six-tube radio receiver function properly. Modifications in wafer design, wire patterns and base plate arrangement provide wide flexibility in meeting equipment requirements.

IDEAS

FLAT PLATE SPRING MOUNTS for heavy equipment provide maximum shock absorption in minimum space. In a unique design developed by General Electric Co. for use with short circuit generators, radial spring feet built-up in layers of separate plates and mounted to the generator stator at a 45-degree angle are utilized to absorb dead weights up to 400,000 pounds and instantaneous torque loads which may run as high as 8,000,000 lb-ft. Maximum angular rotation of the frame is kept to within 0.75-degree and the axial centerline is held to within 30 mils of its rest position, an entirely negligible—as well as remarkable—motion compared to the size of the air gap used in the machines. Key to the effectiveness of the springs is a relative softness to circumferential rotation which acts to cushion the shocks and a high rigidity to gravity deflections which tends to maintain alignment. Compared to conventional helical or leaf spring systems the unusual combination of characteristics achieved by the built-up plate design reduces space requirements to a minimum and facilitates assembly and installation.





POWER SCREWS

Their Design and Application

Friction, thread form and nut design considerations for achieving satisfactory operation and low cost

By George E. Hieber
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PROBLEMS in designing a screw and nut for a given purpose are fairly common. Every designer knows the laws of mechanics, or should know them, and can multiply the load in pounds times the distance of the applied force and divide it by the distance moved by the resulting force to get its measure in pounds. Handbooks show formulas for this, but these apply only to theoretical conditions that never exist in practice. Handbooks may also show a formula involving friction and this, of course, is the one to use because everything that slides, rolls or rubs has friction. Furthermore, the losses due to such friction, especially in the case of screws, may use up the greatest part of the applied energy and the delivered energy will only be from 50 to 20 per cent of the total.

Screw Friction: A designer attempting to fix values to the symbols in any formula involving friction finds he can locate or calculate every one except the coefficient of friction. This coefficient will be listed for bricks on wood or wood on wrought iron or about every arrangement or combination of materials that a civil engineer needs to calculate the angle of repose of a pile of dry building materials. In cases he will also find values for metal on metal combinations, possibly including one for steel on phosphor bronze. However, many of these values will be found to date back to 1829 when shafts were file finished and such a thing as measuring a surface finish in microinches was undreamed of.

Such friction values based on journals cannot be used for two reasons: One is that friction is dependent to some extent on rubbing velocity and most journal bearings run at a much higher rubbing velocity than screws and another is that a shaft rotating in a sleeve bearing displaces itself from its geometric center and forms an oil wedge that practically eliminates metal-to-metal contact.

In thrust bearings of the rocking shoe type the same action takes place. In a screw and nut, however, there is no chance for an oil wedge to develop and so the chance of actual metal to metal contact is great and the coefficient of friction will be higher for the same metals and surface finish as used in a shaft bearing.

Some experimental work in this field was covered in a University of Illinois bulletin dated June 7, 1932, titled, "An Experimental Investigation of

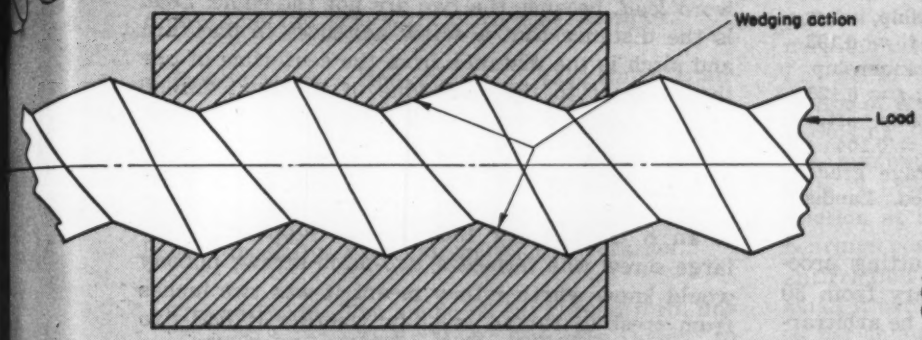


Fig. 1 — Exaggerated screw thread form to show wedging effect of thread angle under load

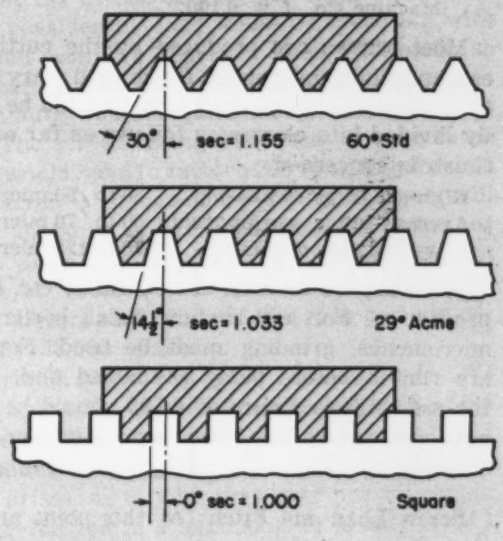


Fig. 2—Right—Wedging friction of power screws increases directly as the secant of one-half the included angle

the Friction of Screw Threads". This is a fairly complete study and although no mention is made as to the measure of surface finish in microinches, the bulletin does go to great length in describing various commercial qualities used. It also gives values of friction for screws when first assembled with their slight irregularities of machining and after run-in to the point where surfaces showed no signs of further improvement. To extend this information Landis Machine Co. made a few experiments as follows:

1. A vise screw, 1⅜ OD, ¼ lead, Acme thread, was cut by diehead with rough and finishing throat chasers, material being free machining medium-carbon alloy steel (3½ Maxel) in the as-rolled condition, with a surface finish 70 microinches. The nut of 80-10-10 bronze was rough and finish tapped, with a resultant surface finish 50 microinches. Finishes were compared under a microscope with standard specimens. Lubricated with SAE 30 oil applied before assembly, test was made with no run-in period. Coefficient of friction = 0.19.
2. A vise screw, 1⅛ OD, 1/5 lead, Acme thread, 50 microinch finish. Nut with 50 microinch finish. All other conditions same as case 1. Coefficient of friction = 0.19.
3. All conditions same as case 2 except screw was worn to 40 microinch finish and nut was approximately 30 microinch finish. Coefficient of friction = 0.18.
4. A lead screw, 1 11/16 OD, 1/6 lead, modified Acme thread with a round top, rough cut by diehead. After the screw reached room temperature, finishing cuts of about one-thousandth inch each were made to finish size. Material, SAE 4140 steel, was stress relieved before machining, nitrided and then polished. Surface finish after polishing, 50 microinches. Aluminum bronze (Ampco No. 18) nut was rough tapped, semifinish tapped, and finish tapped. Surface finish was 50 microinches. SAE 30 oil lubrication was employed. Coefficient of friction = 0.18.
5. A lead screw, 1⅛ OD, 0.364 lead, quadruple thread, modified round-top Acme, SAE 4140 steel, was rough chased and then stress relieved. Threads were ground, nitrided and polished, to produce a surface finish of 30 microinches. Aluminum bronze nut (Ampco No. 18), was rough and finish chased, surface finish 50 microinches. SAE 30 oil lubrication

employed. Coefficient of friction = 0.18.

A summary of the University of Illinois experiments and also the figure which appears safe to use are as follows:

1. High-grade materials and workmanship, after fairly long run-in period, U of I. $f = 0.103$
2. Average grade materials and workmanship, after fairly long run in period, U of I. $f = 0.126$
3. Low grade materials and workmanship, after fairly long run in period, U of I. $f = 0.154$
4. High grade materials, high to average grade workmanship with no run in period, Landis Machine Co. $f = 0.190$.

Most screws are produced by the cutting process and their microinch finish will vary from 30 to 70. Workmanship of cut screws could be arbitrarily divided into classes as follows as far as surface finish is concerned:

High-grade workmanship	30 to 50 microinches
Average-grade workmanship	50 to 70 microinches
Low-grade workmanship	70 to 125 microinches

Accuracy as to lead, thread form, etc. is in like proportion. For any surface finish better than 30 microinches, grinding must be used. Few screws are run in before being assembled and, to be on the safe side, a figure of 0.190 should be used for new cut screws of Acme form, and for the discussion that follows this figure will be used.

Screw Lead and Pitch: At this point and before going into the use of a few formulas, it would be well to stress the importance of exact terms or definitions. Most formulas use the symbol *p* or the word *pitch* when what they should use is the word *lead,* because the two are not the same. Lead is the distance that a screw advances in one turn and pitch is the distance from the centerline of one thread crest to the centerline of the next thread crest. Suppose a screw had 8 threads to the inch and it was a quadruple screw. Its pitch would then be ⅛-inch. Although 99 out of 100 people would refer to it as an 8-pitch screw, it is no such thing—it is an 8 threads per inch screw. Suppose a very large screw was termed a two-pitch screw; nobody would know whether they meant it was two inches from crest to thread crest or whether it had two threads to the inch. Now the ⅛-inch pitch screw mentioned above actually has a lead of ½-inch because it is a quadruple screw and in any formula the lead of ½ must be used and not the pitch of ⅛-inch.

Vise screws and clamping screws form a large percentage of machine screws. In these cases hand power, which is usually assumed at not over 50 pounds, is used over a fairly large distance to obtain forces of the order of several thousand pounds over a short distance. If the screw is of a rather small lead, the ratio of the hand force to the clamping force is great but the distance the hand must travel is also great and time is lost in making

Fig. 3—Table raising screw arrangement for a planer type milling machine

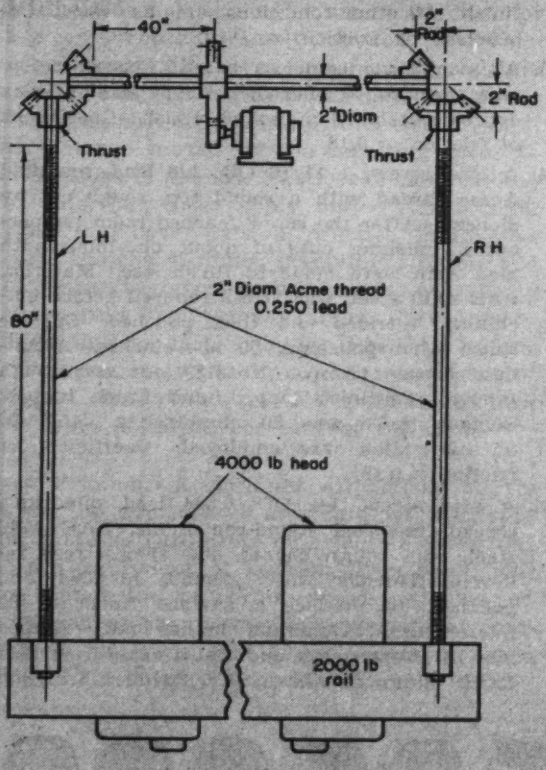


Fig. 4 — Right — Sketch showing interference areas of square thread screw with half-nut

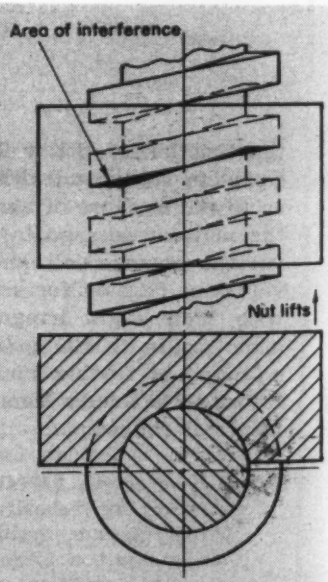
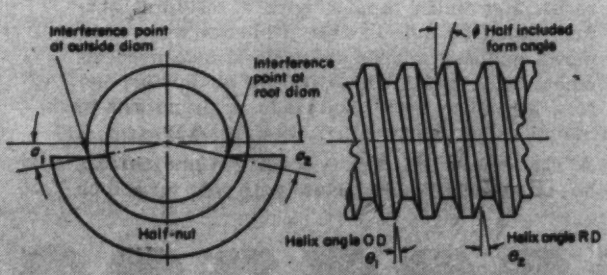


Fig. 5—Below—Method of determining half-nut interference. Interference angle *a* is determined from its tangent which is the quotient of the tangents of the half-included angle and the helix angle



many turns of the handwheel. Conversely, if the screw lead is too large the clamp force will not be great enough, and the helix angle may be so great that it approaches or even exceeds the angle of repose and the vise will fail to stay clamped.

Thread Surface Roughness: Surface finish is important and contrary to most practice it should be rough and it should stay rough, so the vise will stay clamped. Instances have arisen where a vise when new, held perfectly but when the screw smoothed up from use it could not be made to hold, especially when subjected to vibration.

Thread Form: The shape of the thread form has a contributing effect. Most formulas apply to square threads, which are not used today. A square thread cannot be produced as easily as an Acme and besides cost, it has other limitations which will be shown later. Modified 55 and 60-degree included angle thread forms are also sometimes used for power screws.

All commonly used threads affect the friction loss because of their shape. Suppose a screw was made as shown in *Fig.* 1. It can readily be seen that it is almost like a taper pin and the wedging action when load is applied increases the load on the friction surfaces much the same as if the surfaces were rougher or for any other reason the friction was increased. To a lesser extent a 60-degree thread will wedge and to a still lesser amount a 29-degree Acme thread. Wedging increases friction directly as the secant of one-half the included thread angle, *Fig.* 2. For the square thread the sec. is 1.000 and so the drag due to friction remains unchanged. For the Acme thread it is 1.033 and for the 60-degree thread it is $1.155f$. It does not amount to much but it is there and it should be considered.

Calculating Load: Most lead screws on lathes, rail raising screws on planer type milling machines, table moving screws, etc., are cut by either die head, milling or chasing. Generally, they are not ground, either because of greater cost, or because of lack of equipment for grinding long screws. Lack of initial smoothness, therefore, results in a value of $f = 0.190$ when new. With that figure to work with, consider an application to a planer type miller, *Fig.* 3.

Each screw raises 5000 pounds of the load, and general practice is to place the concentrated weight in each head an equal distance from the center of the machine so that the forces are balanced and one screw does not stretch more or do more work than the other due to a heavier load. A square thread used in such an application might have a value of f of 0.184 and since an Acme thread is to be used, $1.033f = 0.190$, which agrees with actual tests. The formula to raise a load is

$$P = \frac{F(l + fc)}{L(c - f')} r$$

where P = force applied at end of radius L, in pounds; L = length of the radius where force P is applied, in inches (2); F = load to be lifted, in pounds (5000); f = coefficient of friction (0.190); c = pitch circumference of screw, in inches (5.498); l = lead of screw, in inches (0.250); and r = pitch radius of screw, in inches (0.875).

Solving for P we get 518 pounds tooth load at the maximum pitch diameter of the bevel gear. This is based on the assumption that there is no friction at the thrust bearings. If these were plain bearings considerable load would be added but with antifriction bearings generally used friction is so small it can be ignored. To raise this rail at 50 inches per minute would require motor horsepower as follows. The screws, being 0.250 lead or four turns per inch, would have to revolve 200 rpm. The force to turn the screw is applied on a 2 inch radius, so it will travel a distance of $4 \times \pi \times 200 = 2520$ inches or 209 feet. Since the force was 518 pounds, we get 518×209 or 108,262 ft-lb per minute, and with two such screws and 1 hp = 33,000 ft-lb per minute, $2(108{,}262)/33{,}000 = 6.56$ hp.

The formula neglecting screw friction is: $P = Fl/2\pi L$ and using the same values as before $P = 99.5$ lbs. Calculating as before, it would only take 1.25 hp, neglecting friction. The point being proved, the question arises, as to why they ever put a formula neglecting friction in a handbook. It is only a trap for the unwary.

A practical point in connection with this example is that since duty is intermittent, the load being moved only occasionally, a 5 hp motor would be applied. Any motor will stand considerable overload if it has a chance to cool between usage, and usage is not of too long a duration.

Torsional and Linear Deflection: A point not usually considered in screw design is torsional deflection. Taking the previous example and checking for deflection, conditions to be considered are: there are approximately 40 inches of 2-inch diameter drive shaft and with the rail down as shown there are 80 inches of 1½-inch root-diameter screw. Formula for torsional deflection is,

$$a = \frac{583.6\,TL}{D^4 G}$$

where a = angle of torsional deflection, in degrees; T = torsion force, in inch pounds (518 lb × 2); L = length of the shaft, in inches (40); D = diameter of shaft, in inches; and G = torsional modulus of elasticity (for steel = 12,000,000).

Solving for the shaft twist, $a = 0.126$-degree and solving for the screw $a = 0.800$-degree. Adding the two together gives almost one degree and since a full turn is equal to 0.250-inch, the rail is 0.00064-inch away from where it should be if there were no twist to the drive.

Far more serious is the linear deflection or stretch of the screw, the formula for which is:

$$e = \frac{FL}{AE}$$

where e = elongation, in inches; F = force or load, in pounds (5000); L = length of the member, in inches (80); E = Modulus of elasticity for steel = 30,000,000; and A = Area of screw (root), in square inches (1.767).

Solving, e = 0.00755-inch. Adding the torsional and the linear deflections the rail is 0.00821-inch lower than it would be if it had no weight. As the rail is raised this figure changes and at a point about half way up it would be about 0.04-inch from its true position.

On a large machine tool like this the exact location of a rail is not important, so long as it remains parallel to the table. Suppose however, that the operator moves both heads to one end of the rail and concentrates all the weight there. One of the rail ends would perhaps be 0.015-inch out of its true position and the other only 0.002-inch. The rail would, of course, be 0.013-inch out of parallel to the table. Once the rail is moved correctly and then clamped, the heads can be moved anywhere as the clamps will hold, but before moving the rail again they must be balanced as shown. The point arises that one screw could be rougher than the other and the greater friction would cause it to wind up more, but since total windup only amounts to an error of 0.00064-inch, a fractional part is too small to consider.

If a horizontal boring mill had a screw of these dimensions to raise a boring head of 5000 pounds, and the operator attempted to bore two holes 40 inches apart, one above the other, depending on the screw and micrometer dials for setting, the holes would be off about 0.004-inch. For this reason end measuring devices are imperative and screws cannot be relied upon, even if they are accurate as to lead.

A designer might reason that he could make the screw large enough to limit this error to a very small amount. However, the horsepower to turn such a screw becomes inordinately large. With a screw 5 inches in diameter the hp would jump from 3.28 to 15.6 and a half-thousandth inaccuracy in a 40-inch vertical position would still be present. Accuracy would be fifteen times greater at a cost of five times the horsepower and the resistance of the screw to turning would be so great that it could not be moved by hand for micrometer setting.

Still another factor enters into design. Where there is considerable moving of the heads a large amount of horsepower is dissipated in heat because of the friction and this heat, being located in the screw, will elongate it due to thermal expansion. This elongation added to that described previously will cause the head to be still lower than its correct position.

In many machines counterweights can be used to balance all or part of the load to overcome much of this trouble. However, for machines having no space for counterweights to balance the assembly of moving parts, the points discussed cannot be ignored.

Antifriction Screws: Why not eliminate this obnoxious friction? Why not use a ball-bearing nut? Unfortunately, the very feature of low friction prevents their use on unbalanced loads that move in a vertical direction. The load would just coast down before the operator could clamp it in an exact position. To prevent the balls from indenting (brinelling) the screw, fairly large balls must be used for heavy loads. More turns in the nut and consequently more balls are used when extra capacity is needed but still for most machine tool loads the balls would be so large that with the necessary clearance between them the resulting lead of the screw would be far greater than that usually needed. Furthermore, a load that would coast down the minute clamps are released is a hazard to the operator. However, this appears to be about the only place they cannot be used, but the places they can be used and are not are many indeed and the fact that they are not used shows a lack of appreciation of the advantages of the ball-bearing nut.

Helix Angle Considerations: Even with regular screws the helix angle must be checked to see that it does not exceed the angle of repose. A remembered case was one where a designer had to use a telescopic screw and due to space limitations made the inner screw too small in diameter for one with a ¼-inch lead. The helix angle and the angle of repose due to the coefficient of friction were so nearly alike that the load, when started went right on down, spinning the handwheel and barking knuckles, until it bottomed with a resounding thump.

One of the reasons the square thread is practically obsolete is that it is difficult and expensive to produce. The Acme type thread is far more economical to produce, but there is a more important reason for its general use. Many lead nuts, as on a lathe, must be split so they can engage and disengage the lead screw. Due to the the helix angle of the screw, the sides or flanks of a square thread prevent a half-nut from lifting freely out of engagement with a screw, *Fig.* 4. Notice that the area of interference where the nut hooks under the flanks of the screw exists everywhere except on the centerline, so only a nut of zero width will lift out of a square screw. Threads with sloped flanks, as in an Acme screw, help this condition, but there still can be interference if the helix angle and thread depth are too great, *Fig.* 5.

In defermining nut interference, consider a 2-inch diameter screw with a single Acme thread of 4 turns per inch. Here the point of interference, *Fig.* 5, for the OD would be: $\tan a_1 = \tan \phi / \tan \theta = 0.03979/0.25862 = 0.1535$ and angle $a_1 = 8$ degrees, 44 minutes. The point of interference for the root diameter would be: $\tan a_2 = \tan \phi / \tan \theta = 0.05317/0.25862 = 0.2060$ and angle $a = 11$ degrees, 39 minutes.

Sliderule calculations are accurate enough for this value as an extra allowance of 1/16-inch or so should be made to allow for variations in machine work, assembly, etc. For economy of manufacture it may be found that a radial cut would be cheapest and in this case the cut should be determined by the point of interference at the root

diameter, or angle a_2. Incidentally, if the points of interference are calculated for all the radii from the root to the crest of the thread it will be found, of course, that the points will not lie in a straight line. The extra allowance mentioned before will also take care of this slight variation.

Design of Split Nuts: There is a principle encountered in half-nut design that is not too generally known and for want of a better name, will be called self-energizing action. This can be shown with a pair of half nuts made as per the preceding calculations, mounted as in *Fig.* 6. The nuts swing out when opening to clear the screw and point *A* is a greater distance from the hinge pin than point *B*. Point *A* with a given friction drag and a long lever arm will pull the nut into engagement more than point *B* with the same friction drag but a short lever arm tends to push it out of engagement. Therefore, the greater the load on the screw, the tighter the nuts will tend to close and the force may be so great that it is extremely difficult to open them.

By simply reversing the direction of the screw the forces reverse and the nuts will tend to open under load. If the screw cannot be reversed, then the parts must be rearranged as shown in *Fig.* 7. With this rearrangement the forces will tend to open the nuts under load. A problem of this nature arose recently in a design where the lead screw nuts did not open although a 125-pound spring was used for the purpose. The spring was raised in power in several experimental steps until it reached 300 pounds and the mechanism still failed to function properly. Furthermore, since the nuts were closed by hand against this spring pressure, it imposed too much of a burden on the operator. After checking into the design the parts were rearranged as shown in *Fig.* 7, so the nuts tended to open rather than close. A 15-pound spring was tried and never failed to open the nuts. It was so unbelievable that a 50-pound spring was finally decided upon to be sure of a margin of safety great enough to overcome dirt, lack of oil, or causes that might keep the nuts from opening.

Nut Wear: Another factor in the design of split nuts is that of wear. Whenever a designer has to use a split nut, he immediately thinks that he can get an added feature of wear adjustment by merely moving the nuts into the screws as they wear. On the drawing board and at first glance this seems to be the case, but it is not true as can be seen from *Fig.* 8. This is an exaggerated sketch to show that any attempt to take up a clearance of the kind shown can only result in a very small line bearing at the centerline. It does not cover the whole nut area and therefore, the pressure per square inch will be high and the wear extremely rapid.

This kind of an adjustment should only be used to take care of machining variations so that the centers of the arcs *a* and *b* can be made to coincide. It would be possible to set the nuts, which were tapped to a larger pitch diamter than the screw, to a tight fit on a special oversize gage screw to obtain the required amount of clearance for this

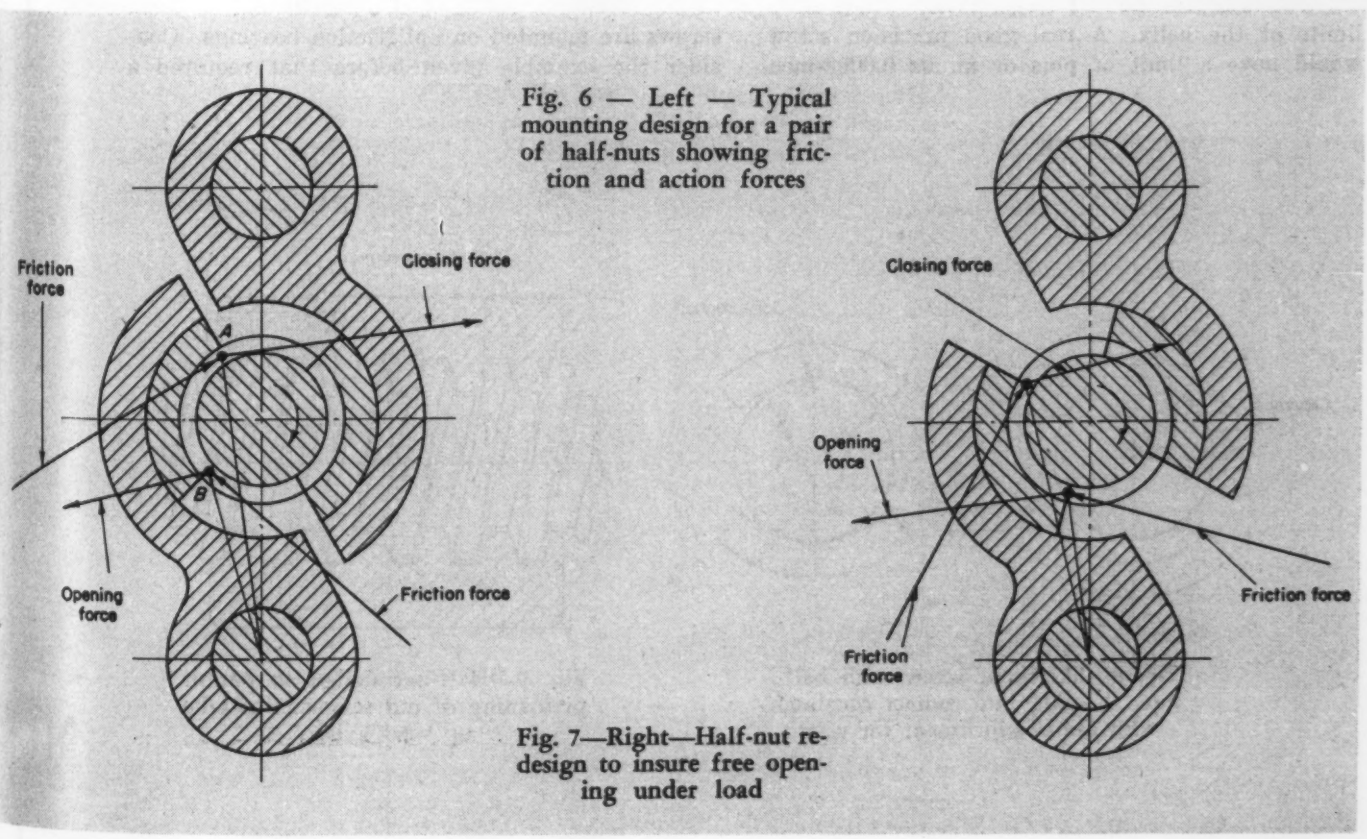


Fig. 6 — Left — Typical mounting design for a pair of half-nuts showing friction and action forces

Fig. 7—Right—Half-nut redesign to insure free opening under load

preferred area bearing.

Another way of taking up wear is to recognize the previous principle and try to take it up endways with a portion of the nut adjustable as very well but unfortunately the screw also wears shown in *Fig.* 9. If only the nut wears, this works and it usually does so in the one spot where all the short work is done. For example, on an engine lathe perhaps 90 per cent of the chasing or lead screw use occurs over a short distance near the headstock. Suppose that after making many pieces a foot long the operator tries to use the adjustment shown. If he takes up the wear on the worn part of the screw the fit will be too tight on the unworn part, and if he sets up the adjustment to a neat fit on the unworn part of the screw it will be too loose on the worn part.

The only reason to take up wear on a screw is to eliminate backlash or play, and the only real answer to the problem is to provide a preload or a holdback force either by means of hydraulics, pneumatics, or mechanics so that a flexible force is acting on a take-up, extra section of the nut, to take care of screw variations. Various patents have been issued to do this mechanically and, of course, it is very simple to load a screw in one direction with a hydraulic or pneumatic force, but they all have one feature in common and that is that the holdback loads must be eliminated when the screw is rotated at a high speed for rapid traversing, otherwise there will be too much heat and wear generated.

Another attempt to improve the wear factor is to provide more wear surface by using a long nut rather than attempting adjustment for wear as it occurs. This looks very good on paper but unfortunately most detail drawings do not show shop limits of the helix. A real good precision screw would have a limit of plus or minus 0.0002-inch lead error in any selected inch, and an overall accumulative error of plus or minus 0.001-inch over a ten-inch length. Mated with a precision nut sized with a final tapping operation, with the work at room temperature and the tap being at least as accurate as the screw, it is still impossible to achieve bearing on the entire helical surface even though the nut might be as short as 2 inches in length. For this reason, it seems silly to make the nut extra long. It might be reasoned that in time the nut and screw will both wear and even out their discrepancies until all surfaces contact at all points and then the wear will be slower. That would be true but it also would be true that the parts would be almost worn out before they were worn in.

The only real answer is precision workmanship with closer limits, better surface finish and proper mounting. The same answer was found early in the auto field. In the very early days bearings and pistons were fit up fairly tight with out of roundness, bad surface finish, etc., quite common. You were warned not to drive a new car too fast as the engine would freeze up and so for a thousand miles you nursed it along and gradually at about 5000 miles it reached its peak performance and from then on it deteriorated until at 20,000 miles the engine needed an overhaul. It was just about half worn out when it was worn in. Today you can take a new car and drive it 50 miles and hour and it will usually give trouble free service for 40,000 to 50,000 miles before needing new bearings or pistons.

Screw Mounting: The mounting of a screw is just as important as the screw thread intself. Obviously a plain bearing will "eat up" just as much energy through friction as the screw itself, and so most screws are mounted on antifriction bearings. Consider the example given before that required a

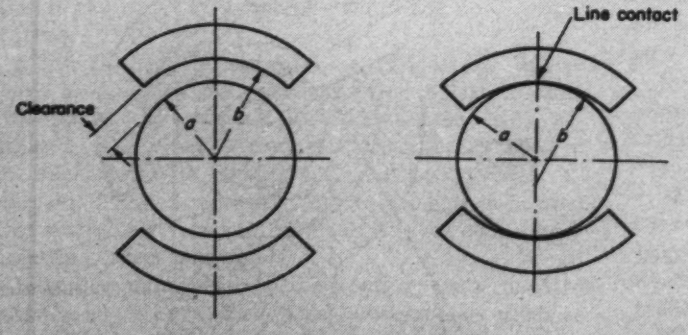


Fig. 8—Sketch of screw with half-nuts showing line contact obtained with radial adjustment for wear

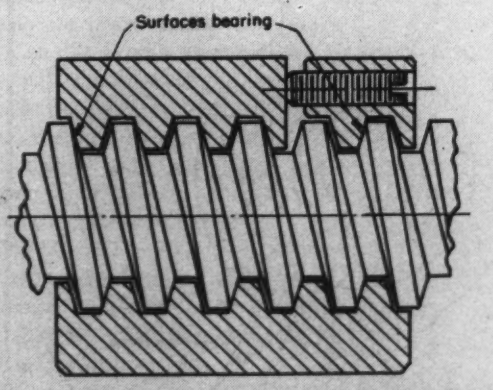


Fig. 9—Half-nut design to permit preloading of nut segments to take up wear axially

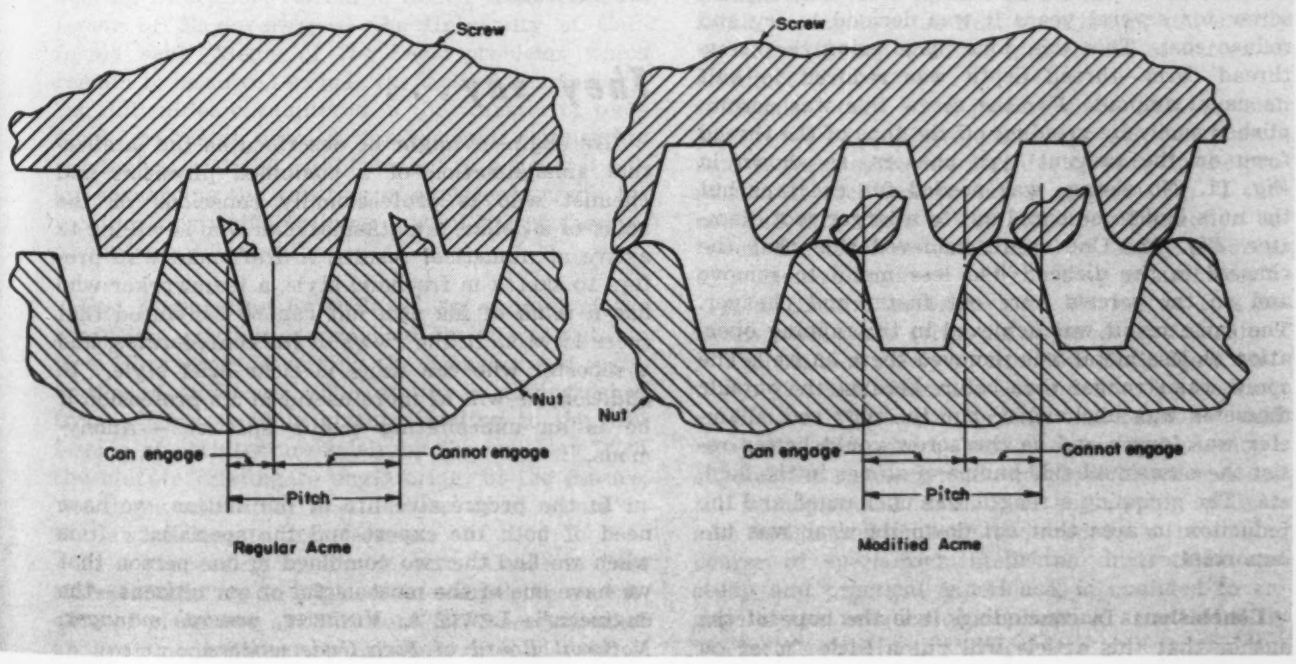
theoretical horsepower of 1.25, but because of screw friction actually needed 6.56 hp to raise the load. It is obvious that if a plain collar bearing is used to take the thrust, that the horsepower required will jump to 11.87. With the 5-inch diameter screw and an equivalently large thrust collar the horsepower required becomes inordinately large. One point to remember in the use of antifriction bearings is that they should bear some relationship in accuracy to that of the screw. It would not do to mount a screw with a lead accuracy of plus or minus 0.0002-inch per turn on ball bearings with a camming action, or end runout of 0.0005-inch. Unfortunately most ball bearing catalogs only give radial runout for the various classes of accuracy but camming runout for all classes of ball bearings will be supplied by makers on request.

Screw Lubrication: One of the troubles in connection with moving a heavy slide is the combined effects of friction and elasticity. Since starting friction is always greater than moving friction and all screws have torsional elasticity, force applied winds up the screw and springs other elastic parts until it reaches a value equal to the static friction, then the slide starts to move. As soon as it does so, however, the friction drops and due to the wind up of the screw, etc., the slide jumps ahead just as if there was a spring behind it. It might move only several thousandths of an inch but when an operator is trying to make an adjustment of one thousandth and the slide sticks and then jumps three he really is in trouble. This problem has received attention lately and there is an oil on the market that has the peculiar property of having a higher running friction than starting friction. Also a small vibrator has been added to slides to cause vibration in a direction crossways to the motion of the screw over a very small amplitude but still enough to break starting friction. Another idea is to coat screws with concentrated sulphur-base oil for their first run-in. It has definite antiweld properties and will usually prevent seizing until the screw is polished up through use. The initial coating is enough. It has only one disadvantage — it discolors the screw slightly.

Thread Shape and Cost: Sometimes the shape of the thread form can be altered either to improve the action of a screw or to lower its cost while still maintaining its quality. Half-nuts are usually made of the regular Acme form, *Fig.* 10. By rounding the tops of both screw and nut it is possible to increase the distance or space in which the nut can be engaged. The depth of the thread form can be increased so that it has the same flank or bearing area as the standard Acme thread form.

On an agricultural machine a screw jack was used at the front end to support it at coupler height when the tractor was removed. The function was only to act as a dead support with possibly a turn to take up the load. Strength, therefore, was important but wear was not as movement covered only a short distance and only at infrequent in-

Fig. 10—Nut and screw thread form modification to increase the engagement distance



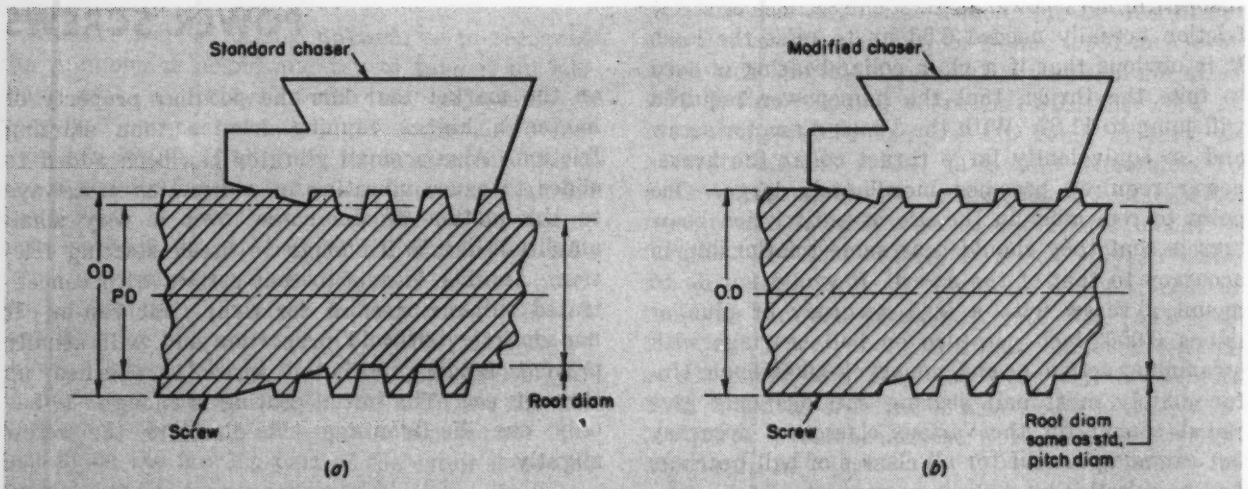


Fig. 11—Standard Acme screw *a* and modified form *b* for cost reduction

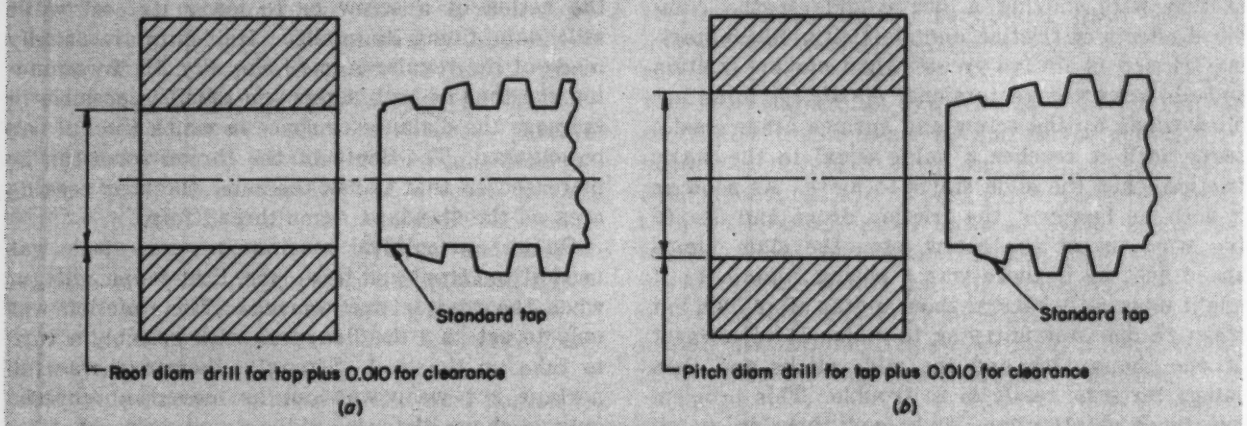

Standard tap
Root diam drill for tap plus 0.010 for clearance
(a)
Standard tap
Pitch diam drill for tap plus 0.010 for clearance
(b)

Fig. 12—Acme thread nut *a* for screw of *Fig.* 11 modified in thread depth for cost savings as at *b*

tervals. The screw chosen was an Acme form because of its quick lead and because standard tools to make it could be obtained. After making the screw for several years it was decided to try and reduce cost. This was done by altering the screw thread form—thread depth was reduced to half its usual amount. For the screw this was accomplished easily by grinding off the tops of the thread form on the tangent type chasers, as shown in *Fig.* 11. No change was needed for the taps but the nuts had to be bored out to a larger root diameter, *Fig.* 12. One result achieved was that the chasers in the diehead had less metal to remove and so the screws were cut faster and cheaper. The same result was achieved in the tapping operation as less metal was removed there as well. The screw was stronger than before because the outside diameter was unchanged, but the new root diameter was larger and so the screw could better resist the occasional side bumps of stones in the field, etc. The stripping strength was unchanged and the reduction in area that cut down its wear was unimportant.

Conclusion: In concluding, it is the hope of the author that this article will put a little "meat on the bare bones" of the formulas usually found in handbooks or at least stimulate a little thought on the subject.

They say . . .

"An engineer might be described as the intellectual amalgamation of a combined physicist and chemist who is professionally conscious of the value of a dollar, a mathematician who is willing to arrive at numerical results, a draftsman who prefers to sketch in freehand style, a teamworker who has a mind of his own but can be convinced that there is value in the views of his confederates, and a reporter who can write in clear brief style. In addition, he will be more useful in his profession if he is an unhesitating public speaker."—Anonymous.

"In the progressive life of our nation, we have need of both the expert and the specialist. It is when we find the two combined in one person that we have one of the most useful of our citizens—the engineer."—LEWIS A. VINCENT, *general manager, National Board of Fire Underwriters.*

Engineering License Laws

Can they be revised to eliminate the present state of confusion?

By Albert Woodruff Gray
Jackson Heights L. I.
New York

ENACTED by Congress in September 1950, the Professional Engineering Registration Act was the last statute to provide much needed regulation of the engineering profession throughout the country, including Alaska, Hawaii and Porto Rico. The effort, however, to protect the profession of engineering from the activities of those who in this as in other professions would travel on the running board of the qualified and capable members of the profession, has been performed only in part. In too many instances the absence of a clear concept on the part of many of the fifty one legislative bodies of the goal to be attained becomes apparent in the statutes, in the vague and uncertain terms of their provisions.

At a meeting of the American Society for Engineering Education, Harold P. Rodes, Assistant Professor of Engineering at the University of California said, "Some of the basic problems which remain to be solved include the lack of terminology, the difficulties encountered in the transfer of technical graduates into a professional engineering curriculum and the establishment of a general policy concerning the granting of experience credit for technical instituted training toward the professional engineer's license."

Can Engineering Be Defined: An example of the confusion existing is provided by the statute in New York State governing the licensing and registration of engineers. This statute is distinguished from a corresponding statute relating to the profession of architecture solely by the omission from the statute relating to engineering, of the phrase, "aesthetic and structural design," that occurs in the law relating to architecture.

In a proceeding in the Supreme Court in that state brought by an engineer to compel the acceptance of plans and specifications for the erection of an apartment house, the absence of a distinction between these legislative enactments was sharply emphasized in the decision of the court. "I think it may be safely said that, speaking of today, there are many elements of service in the preparations of plans for the construction of a building of whatever type, and the superintendence of construction, that may be more properly left to what we now know as as an architect than to what we now know as an engineer. Certainly an engineer is not to be presumed to be 'one who understands architecture.'

"It is to be expected that the regents will shortly provide tests for the determination of what knowledge and experience a man must have in order to practice the profession of architecture. Until they lay down rules that would permit to act as an architect, a man who makes no claim to being an architect, as that term is now universally understood, I think an engineer, as that term is now universally understood, may not hold himself out or act as an architect."

Twenty years have passed since that decision was rendered and two years ago the same court said of these same two statutes relating to the profession of architecture and of engineering, "I cannot find that there is any statutory distinction between the services which may be legally rendered by a licensed engineer and those by an architect."

A distinction as vague and blurred as this between such basic terms as engineer and architect is not confined solely to the New York State statutes. The 1950 federal statute defines an engineer as follows: "The term 'professional engineer' shall mean a person who by reason of his special knowledge of the mathematical and physical sciences and the principles and methods of engineering analysis and design, customarily acquired by a prolonged course of specialized intellectual instruction and study and practical experience, is qualified to engage in the practice of engineering as attested by his certificate of registration as a professional en-

gineer," supplemented by an equally *clear* definition of the term, "practicing engineer."

The definition in the California statute of a "professional engineer" is in part, "A person engaged in professional practice of rendering service or creative work requiring education, training and experience in engineering sciences and the application of special knowledge of the mathematical, physical and engineering sciences, in professional or creative work as consultation, investigation, evaluation, planning or designing of public or private utilities, structures, machines, processes, circuits, buildings, equipment or projects and supervision of construction for the purpose of securing compliance with specifications and design for any such works." In contrast is the 1943 statute of Illinois. " 'Professional engineering' means any professional service such as consultation, investigation, evaluation, planning, design or supervision of construction, in connection with any public or private utilities, structures, buildings, machines, equipment, processes, works, or projects, wherein the public welfare or the safeguarding of life, health or property is concerned or involved, when such professional service requires the application of engineering principles and data."

As a statutory definition of engineering it is the small boy's definition of a giraffe, "There ain't no such animal."

"Briefly stated," said the Illinois Supreme Court in reference to this statute, "the term 'professional engineering' is there defined to mean any professional service where the public welfare or the safeguarding of life, health or property is concerned or involved when such professional service requires the application of engineering principles or data. When an act defines the terms therein used, those terms must be construed according to the definitions contained in the act.

"Here we have a definition that is all inclusive. It includes generally all professional service which requires the application of engineering principles and data. The words 'engineering principles and data' are not defined in the act. They have no fixed and definite meaning.

"An examination of Webster's Dictionary shows that the terms 'engineer' and 'engineering' are used in connection with, and applied to, the activities of numberless professions and vocations, as well as to various activities in countless undefined operations. The use and meaning of these words in modern commerce and industry are practically unlimited.

"The definition of professional engineering is no definition at all. It is but an attempt to delegate to the Department of Registration and Education the power to determine whether a person who renders any services involving the application of engineering principles and data shall be required to secure a license under the act.

"There are no standards or requirements in the act to guide or direct the committee in the formation of its opinion as to what the requirements of the act are. There is no more flexible word in our language than the word engineering. The term includes everything but defines nothing."

The attempt to regulate the practice of the engineering profession by legislation of this character is the poet's "Con-fusion worse confounded." While the year following this decision the Illinois legislature repealed this engineering licensing statute, it nevertheless emphasizes the essential need of uniform statutory provisions governing the practice of engineering and the need for words with definitions of common acceptance which are clearly defined by the statutes themselves.

Need of Uniformity: Uniformity in state legislation relating to engineering laws outlines the only possible foundation on which may be built for the profession the much needed reciprocity by which members of the profession may be accorded the protection their activities deserve and demand.

Of the problems resulting from this lack of uniformity, John L. Waddleton, Manager of the Labor Section, Legal Division, of the Allis-Chalmers Manufacturing Company said recently, "The consulting engineer in the practice of his profession is usually a great deal more peripatetic than either the doctor or the lawyer and in his travels may cross many state lines. He is confronted with varying license laws in the states in which he operates. The excellent work being done by the National Council of State Boards of Engineering Examiners in urging some degree of uniformity among the state licensing laws is about his only salvation from the arbitrary deprivation of his right to work in such states."

In relation to this reciprocity that is essential to the fair conduct of the engineering profession and the adoption by the various states of uniform definitions with an accepted nomenclature, standards of qualifications to be used as a yardstick for registration and licensing need also to be adopted to avoid the consequences that will otherwise surely arise from this interstate reciprocity.

An injuction granted in Ohio a few years ago against the use of the word engineer by the manufacturer of centrifugal casting machines, was later made the basis of an application for the punishment of this manufacturer for contempt. The lower court granted the application and imposed a fine and jail sentence.

" . . . basic problems which remain to be solved include lack of terminology and establishment of a general policy . . ."

" . . . there is . . . no . . . statutory distinction between the services which may be legally rendered by a licensed engineer and those by an architect . . . "

The engineering licensing statute in that state however, specifically exempts "The performance of engineering or surveying which relates solely to the design or fabrication of manufactured products." In setting aside this judgment the Court of Appeals in that state said, "It will be noted that the definition, professional engineering, gives little insight into what activities are included in the act. Briefly stated the term 'professional engineering' is there defined to mean any professional service where the public welfare or the safeguarding of life, health or property is concerned or involved, when such professional service requires the application of engineering principles and data.

"It cannot be said that the mere use of the generic term 'engineer' would be in itself a violation of the act. To warrant a finding of guilt it would be necessary to show that the defendant was actually engaged in the practice of 'professional engineering' or actually holding himself out as engaging in such practice as defined by the act.

"The defendant was president of a company that for a period of time built centrifugal casting machines; built permanent molds and did only the structural detailing of ship loading towers, all of which comes within the exemption. The business activities related solely to the design or fabrication of manufactured products."

The present confusion not only of those who may be engaged in engineering practice but of the courts of the different states as well appears in a recent decision by the Supreme Court of Pennsylvania in an action for services. Here the defense was made that the services, although performed, were engineering services by an unlicensed engineer and hence no recovery for services should be allowed. According to its provisions, this engineering license statute applied to "The practice of civil engineering, mechanical engineering, electrical engineering, surveying or any constituent or part of this or combination thereof, such as architectural engineering, ceramic engineering, industrial engineering, metallurgical engineering, petroleum and natural gas engineering, sanitary engineering and structural engineering."

Of this statute the Pennsylvania court said, "The legislature has thus defined the practice of engineering. By so doing it has drawn up a definition which is broad enough to subject the entire field of engineering to regulation but is nevertheless susceptible of sufficiently precise interpretation when read in the light of the purpose of the act and in conjunction with its other sections, to enable one to readily determine whether his activities are within the scope of the prohibition.

"A more specific definition is improbable for it is clearly beyond the practical capabilities of any regulatory legislation to define the practice of engineering by attempting to enumerate the many and varied types of engineering that now exist and might possibly exist in the future and such a definition must of necessity make use of somewhat general terms."

The Goal: Some time ago Mr. Harry A. Winne, vice-president of the General Electric Company outlined the features to be considered in the establishment of engineering registration statutes. "The practice of engineering is sufficiently affected with the public welfare to warrant proper licensing regulations restricting the right to work in the field. Legislative grants of broad discretionary authority to examining boards will be sustained by the courts unless it is wholly arbitrary or unreasonable. The preservation of the right to work in the profession is to a large extent the responsibility of the profession itself. The right to work as guaranteed by the Federal Constitution is one of the promises we have made to ourselves down through the years and it is one of the promises we give to our children when we send them to engineering schools, to medical schools and to law schools. Where the effectuation of that promise falls within the jurisdiction of your profession, let steps be taken that it be not lost through obsolescence."

Writing in the *Journal of Engineering Education,* of the goals to be attained in the registration of engineers, N. W. Dougherty, Dean of Engineering at the University of Tennessee, said, "We are no longer in the beginning of the registration movement but probably nearing its noontide. The next great step, as I have said before, will be to improve the registration laws to get better enforcement; to make the laws apply to all practicing engineers and to make it easier for engineers to pass from state to state."

REFERENCES

1. Proceedings, National Council State Board Engineering Examiners, 1950-1951.
2. U. S. Stat., 1950-1951, ch. 953.
3. N. Y., Education Law, secs. 7201, 7301.
4. Goldschlag v. Deegan, 258 N.Y.S. 3.
5. D'Luhosche v. Andros, 109 N.Y.S.2d 491.
6. Cal., Bus. and Prof. Code, sec. 6801.
7. Ill. Rev. Stat., 1943, ch. 48½.
8. Krebs v. Thompson, 56 N.E.2d 761, Ill.
9. *Journal of Engineering Education,* vol. 40, pages 567, 571.
10. Smith v. Am. Packing & Provision Co., 130 Pac. 2d 951, Utah.
11. Ohio Soc. Prof. Engineers v. Hulslander, 89 N.E.2d 119, Ohio.
12. Howarth v. Gilman, 73 Atl. 2d 655, Pennsylvania.

" . . . the definition of professional engineering is no definition at all . . . "

" . . . there is no more flexible word in our language than engineering. The term includes everything but defines nothing . . . "

HYDRAULIC ACCUMULATORS

ONE of the first applications of an accumulator was made in the Middle Ages, when a waterfall was harnessed in such a manner as to fill a large container balanced on one end of a lever, the other end of which was connected to a stone door. By deflecting the stream of the falling water into the container, it gradually filled and overbalanced the weight of the door, and thus resulted the magic which raised an idol, opening the secret door into the secret treasure chamber.

Modern application of hydraulic equipment is credited to the development of the first hydraulic press. From that time the press field was dominant, as far as hydraulics was concerned. As the industry grew, motorized pumps were developed, control and regulating valves were introduced, and the accumulator became important, especially where multiple presses were used in connection with a single power source. It was not until very recently that any consideration was given to individually powered machines. Even today, many press shops use single power units with a single accumulator operating a battery or multiple battery of presses.

The aircraft industry must be credited with rapid development of hydraulic systems, components and methods. Here, hydraulic systems were developed to actuate landing gears, dive flaps, bomb doors, bomb-release mechanisms, cooler shutters, engine cowl flaps, and many other intermittent services.

Urgent requirements of lightness and reliability intensified the need for accumulator operation of aircraft systems. Also, from an efficiency standpoint, consideration of the intermittent-duty cycle of the components required that a small pump be applied. But, besides offering the advantages of lightness and minimum horsepower the accumulator could provide a source of energy supplementing and sometimes substituting for the pump in an emergency.

Today, the work-cycle motions in most machine operations are intermittent. Thus the same principle of a smaller pump and a smaller power unit, resulting in a lower cost, simpler, smaller hydraulic system, is available to the designer with the proper approach through application of an accumulator.

DEFINITIONS

An *accumulator* is an apparatus by means of which energy or power can be stored to do useful work. For instance, an electric storage battery accumulates energy from an automobile generator. A storage tank on an air compressor accumulates pneumatic power.

A *hydraulic accumulator* is a mechanism in which potential energy is stored in a practically incompressible fluid. This potential energy may be in the form of gravitational force, the elasticity of springs or the compressibility of gases.

A *hydropneumatic accumulator* is a mechanism in which potential energy is stored in an enclosed gas chamber contained within a fluid chamber.

ENERGY CAPACITY AND STORAGE

Unusually quick response and precise control available in hydraulic actuating systems are due to the fact that the hydraulic fluid is virtually incompressible. Hydraulic fluid, as normally used in industry, when raised to 5000 psi will shrink about 1.7 per cent in volume. If oil filled a vessel completely and then was raised to 5000 psi, as soon as only 2 per cent of this volume was released the pressure of the oil remaining in the vessel would be zero. Therefore, hydraulic fluid, being a liquid, has no appreciable dynamic-power storage qualities. Gases, however, have a high degree of compressibility and can store energy when merely compressed. Combining liquids and gases in controlled volumes within an enclosed vessel under controlled pressure produces a hydropneumatic accumulator whose dynamic energy can be utilized to do useful work.

1—Their Principles and Uses

By Edward M. Greer

President and Chief Engineer
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FUNCTIONS OF THE ACCUMULATOR

Pressure Storage: For intermittent work-cycle motions the accumulator can be used as a storage battery to provide the actual source of energy, the pump being used simply as a means of storing energy in the accumulator. It can also be used as an auxiliary source of power to supplement the output of the pump during peak demands beyond the capacity of the pump. This principle can also be applied to operate secondary and emergency circuits.

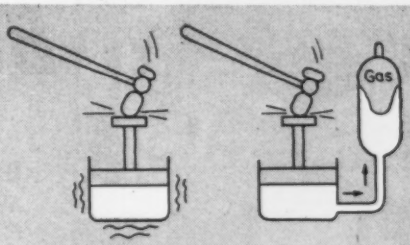
Pulsation and Shock Absorption: In the normal development of hydraulic power, various types of pumps are used. The modern pump in itself takes many familiar forms. In all cases these pumps deliver pulsating flow. The degree of pulsation varies with each type of pump. The higher the pressure, the greater is the effect of pulsations. In piston-type pumps, which are by far the best for high pressures, pulsations are most prevalent. Pulsations have very detrimental effects on hydraulic systems, and cannot be tolerated in some cases. A properly applied accumulator will reduce and often eliminate pulsations in the system.

When fluid flows rapidly within the confines of a pipe and is stopped suddenly by a valve closing, the result is similar to that of a ball hitting a solid wall. The reactive force causes a bounce. This surge can develop pressure peaks far beyond the rated burst pressure of pipes and fittings and is in effect, the greatest cause of pipeline failures. Even when no failures occur, noise and vibration are highly objectionable. With an accumulator strategically located in the system, these shocks and surges are absorbed by the cushioning effect of entrapped gas.

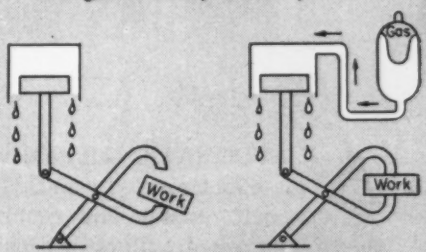
Pressure-Volume Compensation: In closed or pressure regulated circuits an accumulator is used to compensate for internal or external leakage in the system. It is also used to maintain constant pressure by absorbing or expelling hydraulic fluid which otherwise would affect the pressure due to thermal expansion or contraction, or as an absorption chamber where the ram must return to a given position after it has been displaced from its position.

Transfer Barrier: In some systems it is necessary to develop pressure in one side of the circuit and transfer this pressure as developed into another fluid without the possibility of having them intermix. The flexible diaphragm in the accumulator acts as a barrier between these fluids without diminishing the pressure.

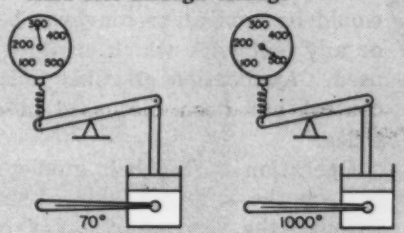
Fluid Dispenser: Liquids and lubricants can be stored in an accumulator to be dispensed at will under controlled pressures.



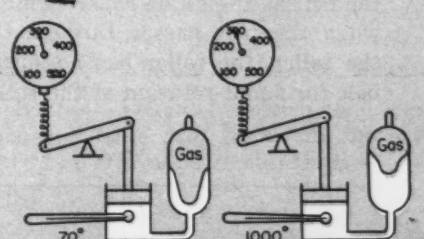
Accumulator absorbs shocks which otherwise would be transmitted throughout the hydraulic system



Accumulator maintains pressure in work-holding system by replenishing fluid lost through leakage

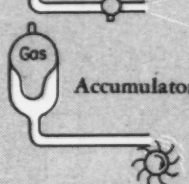


Fluid pressure varies with fluid temperature in closed hydraulic system



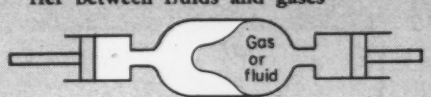
Accumulator in system maintains constant pressure despite fluid temperature variations

Accumulator dispensing fluids or greases under pressure



Accumulator stores potential energy

Accumulator acting as transfer barrier between fluids and gases



Self-Adjusting Belt Guider

By Stephen E. Amos
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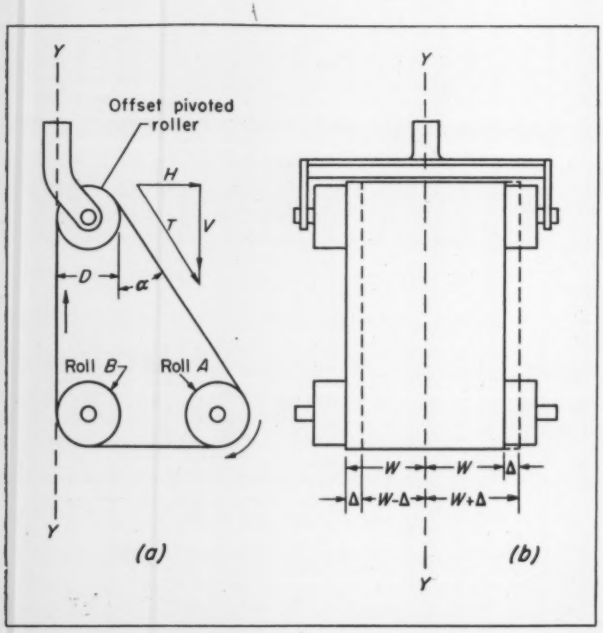
AN AUTOMATIC belt guider comprising a single offset pivoted roller can be used to guide a belt quickly and accurately without the need for crowned pulleys or sensing elements, such as feelers or controls of any kind. View *a* in the accompanying illustration shows the roller as it would be applied to conveyor belts, sanding belts, or any belt with which crowned pulleys cannot be used. Application of guide rollers to web guiding control has been discussed in several recent articles.*

Operation of the belt guider is as follows: the belt on the approach side of the roller must pass through the vertical axis *Y-Y* of the offset pivot, view *a*, to avoid introducing sideward movement of the belt as the guide roller swings. In other words, when the belt passes through the neutral axis of the roller, the roller has no sideward effect on the belt for small rotation of the roller about the offset axis *Y-Y*. The belt must then leave the roller at some angle α sufficient to create a horizontal force component *H* about the pivot axis *Y-Y*. When the belt is centered on the roller, force *H* has equal moment, as shown by $HW/2 = HW/2$, view *b*. If for some reason the belt moves sideward by an amount Δ, an unbalance in the moments would result, and the equation would be changed to $(H/2)(W+\Delta) = (H/2)(W-\Delta) = H\Delta$.



In order for the roller to sense a small degree of runout, the friction in the roller offset pivot would have to be reduced to the lowest possible value. Over and above the torque required to overcome friction, the moment due to sideward runout would tilt the roll slightly about its offset axis *Y-Y* and in so doing would rapidly guide the belt back toward balance. The width of the belt is immaterial as long as sufficient moment is developed to actuate the roller about its offset pivoted axis.

The degree and speed of correction are functions of the diameter *D* of the guiding roller, the degree of runout, and the lineal speed of the belt. The larger the diameter *D*, the greater the throw of the roller and the greater the sideward correction the roller will handle.

The angle α has not been determined accurately but appears to be approximately 30 degrees for the average arrangement.

The length of the belt along the *Y-Y* axis should be approximately the width of the belt to allow freedom of turning of the offset pivoted roller. Similarly, for best operation, the length of web on the offgoing side between the pivoted roller and roll *A* should be at least equal in length to the width of the belt.

Successful tests have been made on web belts up to 30 inches wide and running as fast as 1000 ft per minute. Even higher speeds should be possible with the guiding roller.

*Stephen E. Amos—"Web Guiding Control," MACHINE DESIGN, Sept. 1951, Pages 159-162.
J. A. Baring—"Control of Moving Webs," MACHINE DESIGN, Sept. 1953, Pages 151-157.

Human Factors in

MACHINE INDEXING

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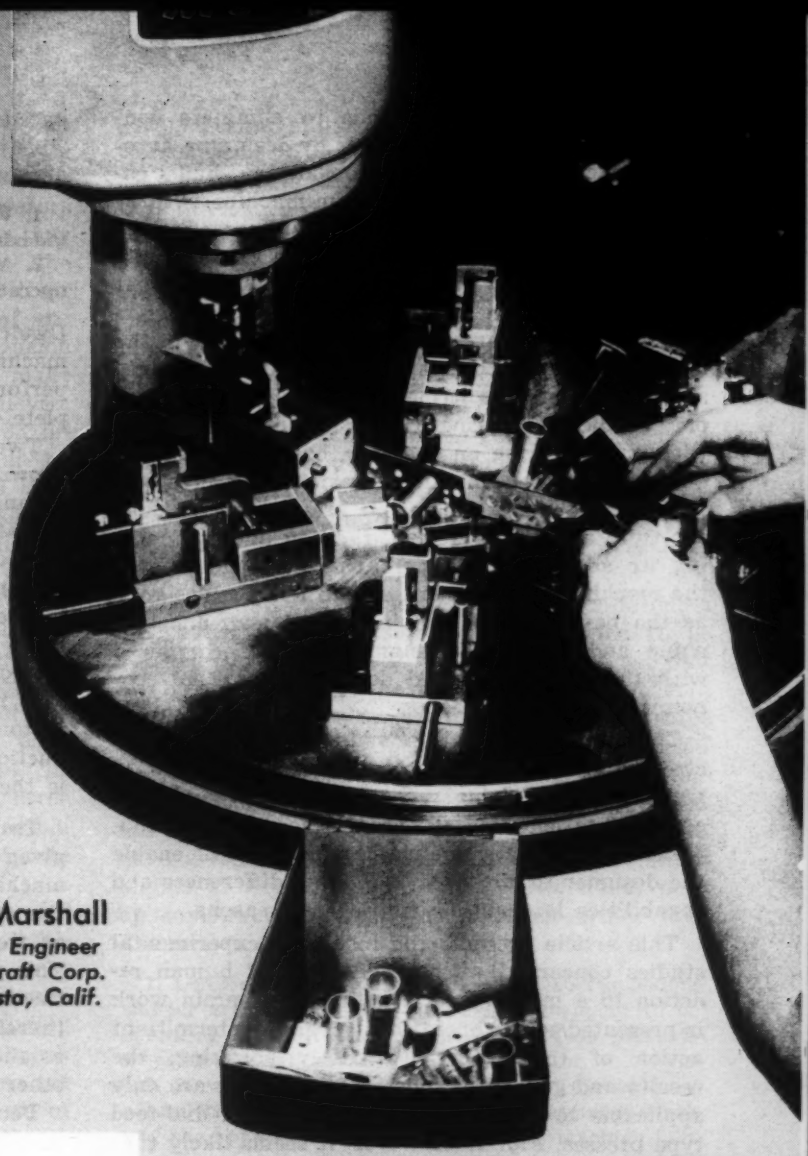


Photo, courtesy Denison Engineering Co.

Fig. 1—Above—Optimum design requires a knowledge of human capabilities as well as economic and mechanical factors involved

Fig. 2—Below—Operators inserted two 11/16-inch diameter balls into holes in the index plate of this machine during tests

IN GENERAL, there has always been a great tendency on the part of machine designers to attempt to eliminate the human operator rather than to design a machine that best utilizes his anthropometric and psychological capabilities. Reasons for this are threefold. First, it no doubt seems much more interesting and challenging to design something big and complex than it is to clean up existing designs. Second, the largest engineering departments are in the larger companies where mass production is generally the rule. Thus, the talent quality for engineering automatic machines and the possibility of an economic payoff are more likely to occur simultaneously in such a situation. Third, and perhaps most important, it generally seems easier to eliminate the operator than it is to live with his human foibles.

Undoubtedly, the cause is that there is little concrete design data which indicates to the machine designer how best to utilize the psychological differences and anthropometry of man during the design stage. In effect, this poses an "either-or"

situation. The designer tends to eliminate consideration of the operator either by designing automatic machinery or by not considering man's capacities and capabilities when the machine is to be operated by man. Consider the resultant effect of such a tendency. Designs where the human operator is to be used will tend to be not as efficient (i.e., relative time per minute production) when human capacities are not taken into account in the design, as when they are adequately taken into account. From this it may be reasoned that economy studies comparing a fully automated machine with one requiring an operator, but designed without consideration for the human factor involved, will tend to show too low a breakeven point for the fully automated design, thereby unduly favoring its adoption. It may thus be concluded that the machine or equipment should first be designed as the best possible combination of man and machine and that *this* design should be compared with the fully automated design before final economic selection is made.

Consideration of this human link has also been stressed by many psychologists and engineers as a means of obtaining greater worker productivity and job satisfaction. Thus the need for psychological and anthropometric data which will enable the designer to allow for individual differences and capabilities is desirable for several reasons.

This article presents the results of experimental studies concerned with two aspects of human reaction to a machine-paced situation wherein work is presented to the operator by regular intermittent action of the machine. Strictly speaking, the results and generalizations presented here are only applicable to the design of manually fed dial-feed type presses, *Fig.* 1. However, it seems likely that individual differences as observed in the studies will occur in about the same range and relationship in the more general situation, i.e., the machine paced situation. At least an insight as to the possible effect should be afforded. The studies provide design data in answer to the following questions:

1. What effect have variations in the speed of the indexing machine upon operator performance?
2. What effect have different dwell ratios upon operator performance?

Dwell ratio is defined as the ratio of the time the machine (or line) is stopped for the operator to perform his useful work to the time of one complete cycle of the machine.

Two separate studies were run on the machine shown in *Fig.* 2 for the purpose of collecting data to answer these questions. Purposely simple, the operation performed consisted of grasping an 11/16-inch diameter steel ball bearing in each hand and transporting and inserting the bearings into holes in the dial plate which indexed one pair of holes at a time. The number of balls successfully inserted by the operator was counted electronically and recorded at the end of each minute on an Automatic Impulse Counter Recorder. Average production of the operator per minute of the test run is the statistic used to represent his performance.

Test 1—Machine Speed: Twelve operators were given a series of one-half hour tests, at increasing machine speeds. The experiment was made with the assumption that the operators were relatively as well trained at each subsequent speed tested. This permits the inference that the results indicate the range of individual differences, and it should therefore be pointed out that the production rates as shown here have no meaningful significance for other than this test.

Performances of three typical operators, *A, H* and *M,* and the group average are shown in *Fig.* 3. Maximum production achieved by each of the twelve operators is shown in *Fig.* 4. If the operator were to have successfully inserted a bearing into each

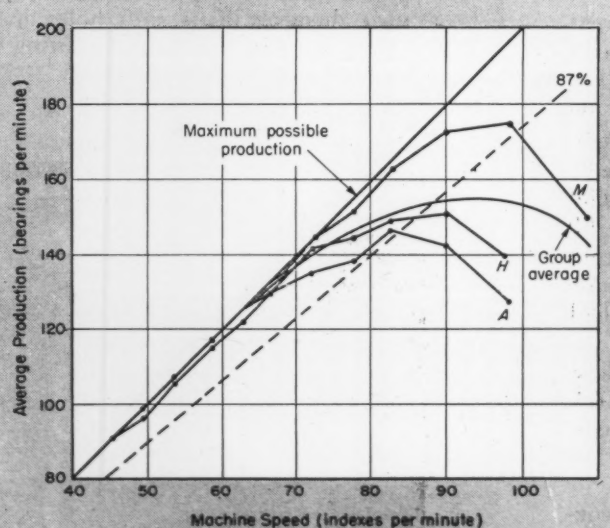


Fig. 3—Average production per minute versus indexing speed for three operators

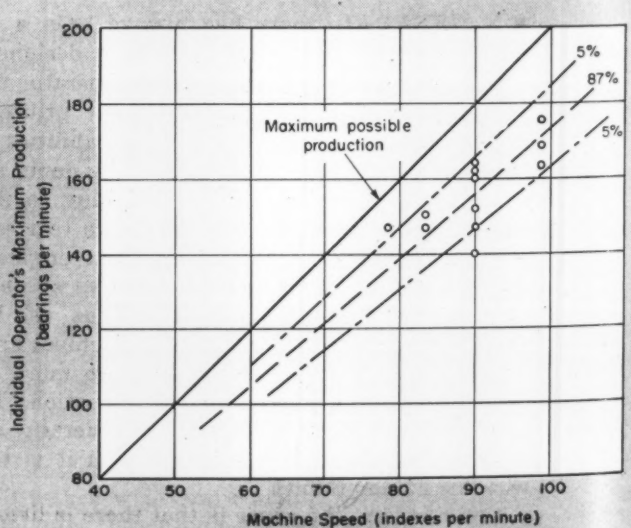


Fig. 4—Maximum production rates attained by three operators and group average

hole presented him by the machine his production curve would have followed the line marked.

MAXIMUM POSSIBLE PRODUCTION: In all cases, as noted by individual points in *Fig.* 4, the operators achieved their own maximum production when they missed considerable opportunities offered by the machine. In fact, ten of the twelve achieved their maximum production within ±5 per cent of the constant 87 per cent line shown. At the conclusion of each test run, the operator was asked to make statements concerning the production he achieved. In every case, above the machine speed of 63 indexes per minute, the operator stated that he thought he had made fewer total insertions than during the preceding run which was at a slower speed, and that the present run was certainly his peak performance, if the preceding were not.

CONCLUSIONS AND DESIGN IMPLICATIONS: Individual operators have widely varying production rates. Thus machines if designed to be adjustable to the optimum speed for each individual operator should result in an increased productivity of the individual and any group of which he is a part.

The operator's subjective feeling concerning his production rate is not accurate and is most often actually misleading as an estimate of his actual production rate. Designers should be wary of data compiled solely from this source.

The production versus machine speed curves for all operators are similar, showing a gradual leveling off, a peak and finally a sharp decline.

There seems to be some evidence that maximum response (peak production) to the paced situation is a constant for all operators. In this study, peak production occurred at ±5 per cent of a constant percentage line of 87 per cent for all but two of the operators. These were found subsequently to have been only partially trained.

Test 2—Dwell Ratios: Thirty-seven operators were trained and tested at three different dwell ratios in a randomized block type experiment. In all cases the machine speed was set at 90 indexes per minute which approximated the group maximum production point, *Fig.* 3. Dwell ratios of $\frac{2}{3}$, $\frac{1}{2}$ and $\frac{1}{3}$ were obtained by installing three different cams in the mechanism.

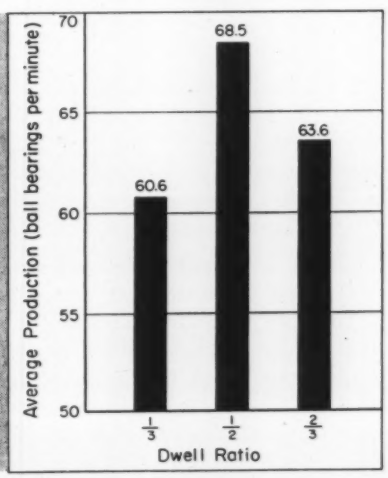


Fig. 5—Production with machine dwell ratio of 1/2 exceeds that for dwell ratios of 1/3 or 2/3

The design philosophy of most press manufacturers seems to favor the longer dwell ratios. The reason for this seems to be based on the belief that the longer the dwell (speed being a constant), the more time the operator will have to perform the work required, thereby resulting in a more efficient output. Also, metal working conditions or the relative movement of the ram to the work may require the work to be stationary as long as possible during the machine cycle.

At any rate a dwell ratio of $\frac{2}{3}$ represents the prevalent design condition. In some conditions the longer dwell is not required for metal working or machine interference considerations, and the resultant quicker action of the moving parts actually requires a heavier design to handle the correspondingly greater forces of acceleration involved.

Test results are shown by *Fig.* 5. The differences shown were tested statistically and found to be statistically significant at better than the 5 per cent level. It is quickly seen that the dwell ratio of $\frac{1}{2}$ permits best operator performance of the three dwell ratios tested. Operator performance is 7.7 per cent better than with $\frac{2}{3}$ dwell ratio and 13 per cent greater than with $\frac{1}{3}$ dwell ratio. While intermediate values of dwell ratio if tested, might have given better operator performance, it seems logical to expect a curve shape that would peak up somewhere between the extremes either way. Reasons for this are:

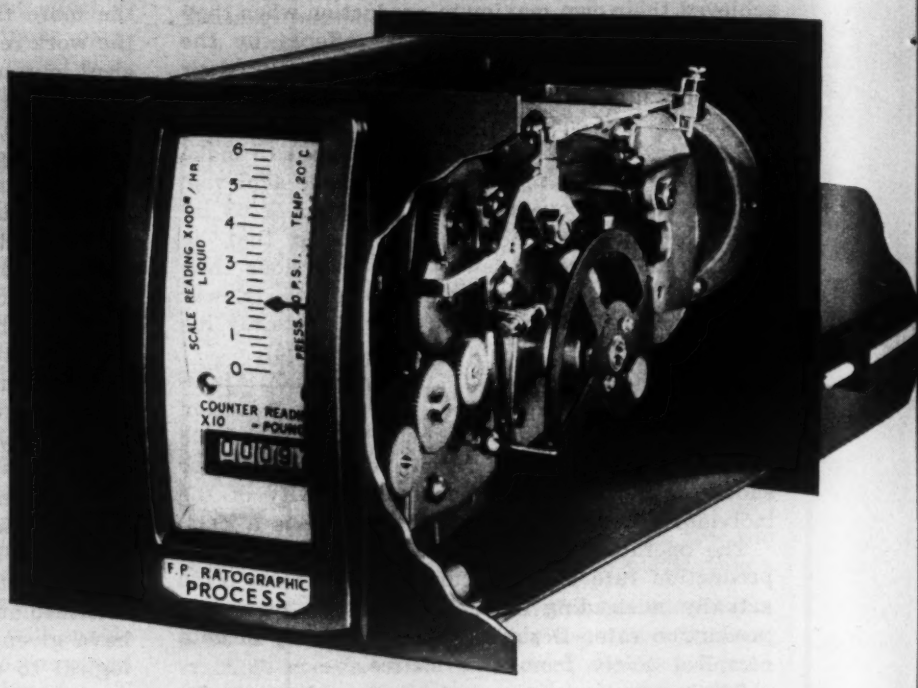
1. Longer dwell ratios with their corresponding shorter action time make the machine appear to be operating faster than it actually is. This presents a psychological barrier to the operator.
2. Shorter dwell actually robs the operator of needed time within which to perform required work and the apparent slower motion of the machine lulls the operator into a false sense of the speed required.

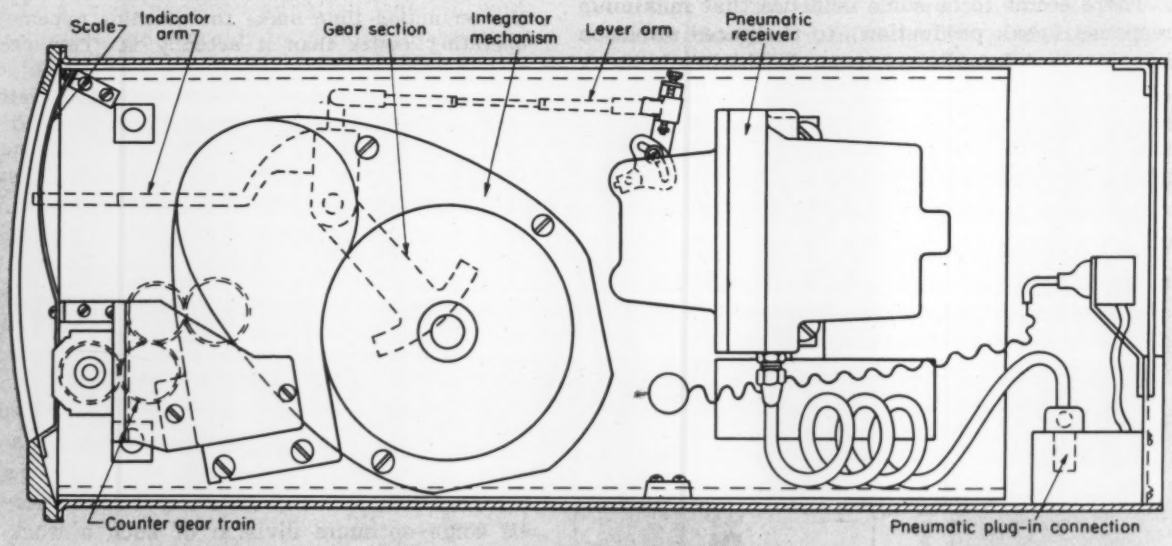
CONCLUSIONS AND DESIGN IMPLICATIONS: Where the operation is simple a dwell ratio of $\frac{1}{2}$ permits better utilization of human capabilities. Where operations can be kept simple, it is suggested that serious consideration be given to the dwell ratio specified. It is evident that the dwell ratio does have an effect on operator performance. There may be an implication here that the division of the cycle into equal parts tends to permit a better sense of timing and balance in the operator's mind. At any rate, for any given operation there must be some optimum division of such a work cycle. Designers should keep in mind that in machine paced conditions the apparent speed of the machine and hence the sense of the amount of energy required of the operator may be greatly affected by the dwell ratio chosen. This can adversely affect the operator's ability to produce most effectively.

Effective design must consider economic and humanic factors in addition to pure functional or mechanical design. The results of these experiments are another indication that the anthropometry and psychological reactions of man are indeed an important factor in the efficiency of man at machine. If designs reflect the individuality of man, perhaps the need to eliminate the human factor will not be as necessary an end in design.

Integrator Totals Liquid Flow Rate

AN INTEGRATING unit and standard five-digit counter senses and totals liquid or gas flow 24 times per minute, permitting accuracies within 1 per cent of full scale. The miniature Ratographic integrator-indicator unit manufactured by Fischer & Porter Co., measuring 6 by 6 by 14⅝ inches, also indicates instantaneous flow rate.

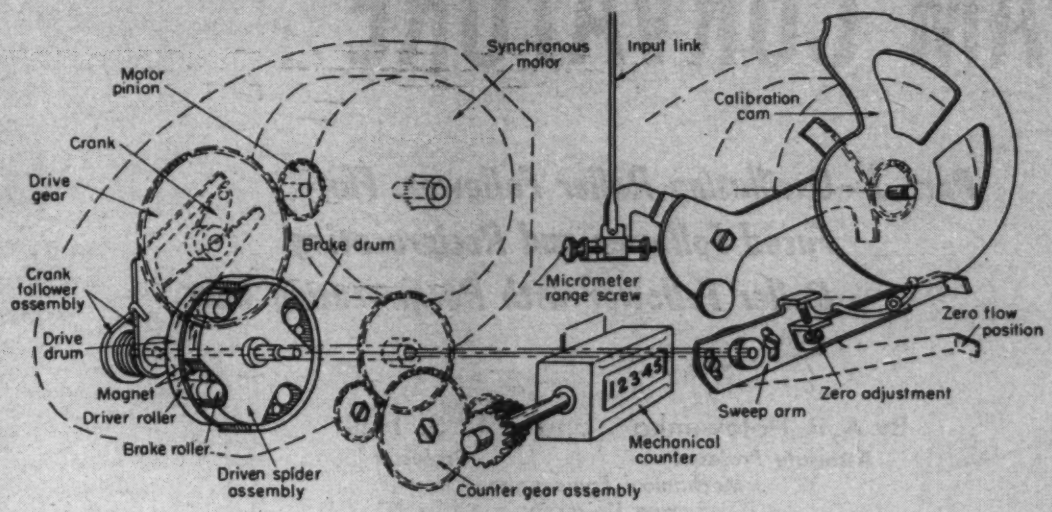




Instantaneous flow rate is indicated on a vertical strip by a pointer attached to the integrator calibration cam. The pointer and cam are both positioned by a bellows-operated pneumatic receiver which operates at signal pressures of from 3 to 15 psig.

Calibration cam, representing the calibration of the primary instrument in polar co-ordinates, is rotated by the input link and sector gear to a position corresponding to the pneumatic receiver air pressure.

Every 2.5 seconds the sweep arm is moved upward from its zero-flow position by a 100-rpm synchronous motor driving one arm of a crank follower assembly; the second arm, tied to the first by a torsional



overtravel spring, drives the sweep arm. Angular movement of the sweep arm is limited by striking the cam face.

Return stroke of the arm determines the integrator count by rotating the drive drum of the one-way roller clutch clockwise. Rollers are held lightly in position by cylindrical magnets, giving fast clutch engagement. As the drive drum ceases its forward motion and starts its return stroke, the rollers are freed and the spider, which drives the counter, stops its motion. To prevent any retrograde motion, a fixed brake drum with a separate set of rollers and magnets locks the spider to hold it fixed until the next forward movement of the drive drum frees the spider.

Indexing Units Built In "Packaged" Chassis

PROVIDING versatility of operation and mounting methods was the prime design purpose in new turret indexing units built by Swanson Tool and Machine Products Inc. Providing a basic chassis for light machine tools, the unit is designed for several types of drive and with mounting methods for a variety of accessories. The basic indexing method is a barrel type cam, of which 90 degrees is used for indexing and the remainder for dwell time. The cam releases contact during the stationary part of the cycle, and an independent wedge-shaped locking device engages two cam follower rollers to index during this portion of the cycle.

Three worm-gear ratios can be provided in any unit, two different speed motors, and variable-pitch V-belt sheaves, to give indexing speeds of 176 to 4700 indexes per hour and dwell times from 0.5 to 15.3 seconds.

CAM CURVATURE

Part 3—Oscillating Roller Follower, Flat-Faced Follower and Reciprocating Roller Follower with Reciprocating Cam

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CONCLUDING this series on the analysis of cam motion and the determination of cam radius of curvature, this article discusses two types of oscillating follower systems and one consisting of a reciprocating roller follower working with a reciprocating cam.

Oscillating Roller Follower

Determining the velocity and acceleration of an oscillating roller follower working with a cam of known contour is comparable to the procedure already discussed in relation to reciprocating roller followers (Part 2, September issue), except that the roll center has a normal component of acceleration which can be computed. Equations for a complete solution are given in the following section.

Radius of Curvature: For the problem of determining the cam radius of curvature for a given cam and follower motion, *Fig.* 21*a* shows the assumed data. The first step in the solution is to calculate the velocities of point P_2 on the cam and the coincident point P_4 on the follower: $V_{P2} = (O_2P)\omega_2 = 1.496(100)/12 = 12.46$ ft per sec; $V_{P4} = (O_4P)\omega_4 = 2.000(59.0)/12 = 9.83$ ft per sec. With this information the following vector equation can be solved by construction of the corresponding vector triangle as shown in *Fig.* 21*b*.

$$V_{P4} = V_{P2} \twoheadrightarrow V_{P4P2} \quad \ldots\ldots (36)$$

The relative velocity vector V_{P4P2} is directed parallel to the common tangent between cam and roller. Hence a perpendicular to this direction through the roll center is the common normal between cam and roller, and contains the point of contact B as well as the center of curvature C, as shown in *Fig.* 21*c*.

The next step in the solution is to write the acceleration vector equation:

$$A_{P4} = A_{P2} \twoheadrightarrow {}_nA_{P4P2} \twoheadrightarrow {}_tA_{P4P2} \twoheadrightarrow {}_{cor}A_{P4P2} \quad \ldots\ldots (37)$$

The acceleration of point P_4 can be calculated from the given information concerning motion of the follower. That is,

$$A_{P4} = {}_nA_{P4} \twoheadrightarrow {}_tA_{P4} \quad \ldots\ldots (38)$$

where ${}_nA_{P4} = (O_4P)\omega_4^2 = 2.000(59)^2/12 = 580$ ft per sec^2, and ${}_tA_{P4} = (O_4P)\alpha_4 = 2.000(16{,}260)/12 = 2710$ ft per sec^2. The acceleration diagram is started by adding these two components of A_{P4} as shown in *Fig.* 21*d*.

Of the other terms involved in the foregoing equations, the following can be calculated: $A_{P2} = {}_nA_{P2} = (O_2P)\omega_2^2 = 1.496(100)^2/12 = 1246$ ft per sec^2, directed from P toward O_2, and ${}_{cor}A_{P4P2} =$

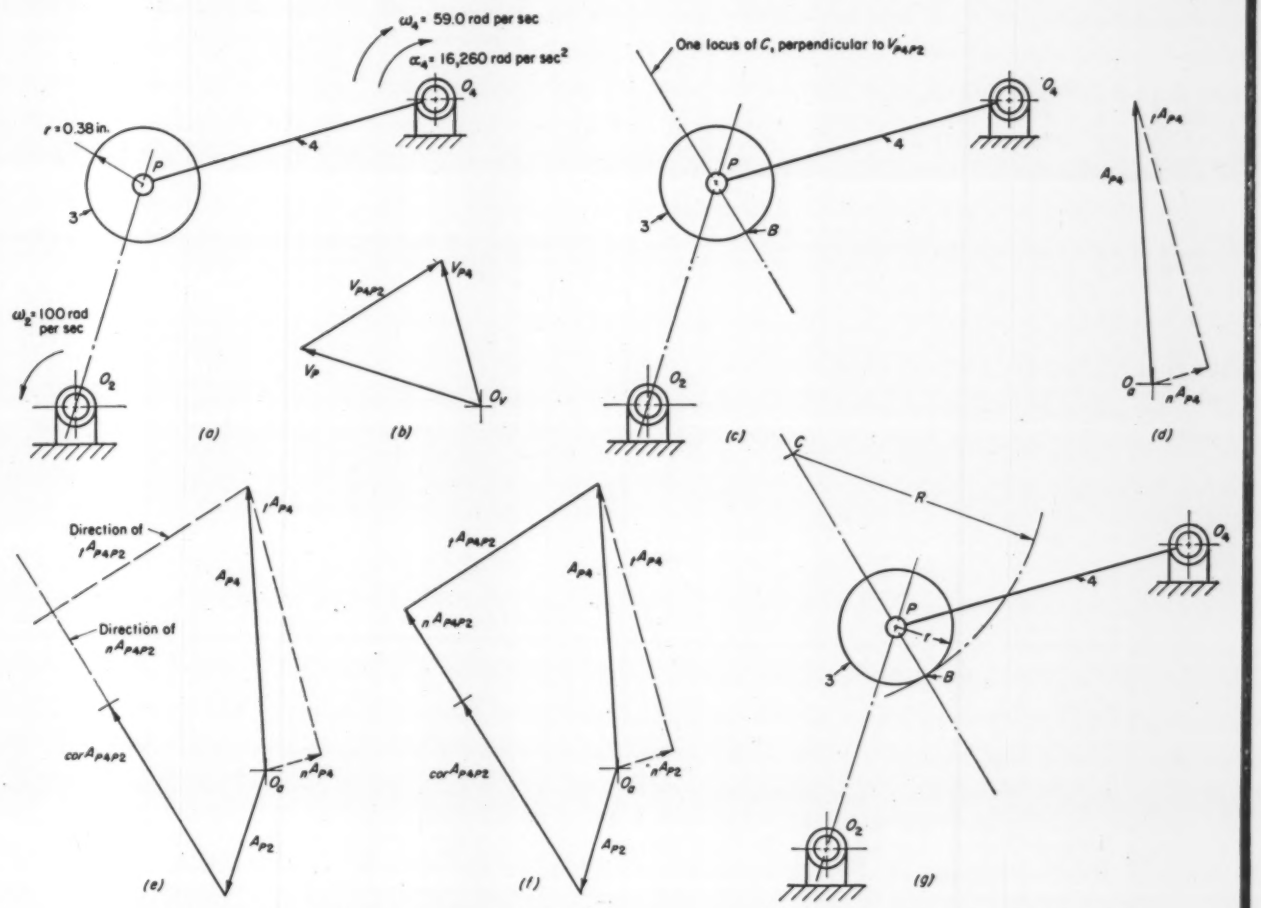


Fig. 21—At *a*, roller follower of center P oscillating about point O_4. Position of follower and acceleration and velocities are known. Problem is to find radius of curvature of cam centered at O_2. Successive stages are: *b*, velocity polygon; *c*, common normal between cam and follower, containing center of curvature, found from *b*; *d*, start of acceleration polygon; *e*, continuing construction of the acceleration polygon; *f*, completion of acceleration polygon; and *g*, location of center of curvature

$2(V_{P4P2})\omega_2 = 2(10.91)(100) = 2182$ ft per sec^2, directed from B toward P, found by rotating the V_{P4P2} vector 90 deg in the sense of ω_2.

The remaining two terms are known in direction only; $_nA_{P4P2}$ is directed along the common normal and $_tA_{P4P2}$ along the common tangent between cam and roller. With this information, the acceleration diagram can be continued as shown in *Fig.* 21*e*. The vectors A_{P2} and $_{cor}A_{P4P2}$ are added, starting from the pole point, O_a, of the diagram. Then, by drawing a line in the direction of $_nA_{P4P2}$ through the tip of the $_{cor}A_{P4P2}$ vector, and a line in the direction of $_tA_{P4P2}$ through the tip of the previously drawn A_{P4} vector, the diagram is closed, *Fig.* 21*f*. The important results are the magnitude and sense of the $_nA_{P4P2}$ vector. From the magnitude the distance from P to the cam center of curvature C can be computed: $(CP) = (V_{P4P2})^2/{}_nA_{P4P2} = (10.91)^2/(1082) = 0.110$ ft or 1.32 inches. The $_nA_{P4P2}$ vector always points from P toward the center of curvature. Hence C is located as shown in *Fig.* 21*g*. The radius of curvature in this example is then: $R = (CP) + r = 1.32 + 0.38 = 1.70$ inches.

Exact Radius of Curvature: As shown in *Fig.* 22 the diagrams for this case are the same as for the offset reciprocating roller follower, *Fig.* 20*b*, with the addition of one acceleration component, $_nA_{P4}$, due to the curvature of the path traveled by the roll center. The development of the equations follows the same procedure as for the reciprocating follower. From the acceleration diagram, *Fig.* 22*b*,

$$\cos\theta = {}_{cor}A_{P4P2} - {}_nA_{P4P2} \quad \frac{[{}_tA_{P4} + A_{P2}(\cos\gamma + \sin\gamma\tan\theta) - {}_nA_{P4}\tan\theta]}{\ldots\ldots\ldots\ldots\ldots\ldots} \quad (39)$$

However,

$$ {}_nA_{P4} = \frac{V_{P4}^2}{L} \quad \ldots\ldots (40) $$

From the velocity polygon, *Fig.* 22*c*,

$$ V_{P4} = V_{P2} (\cos\gamma \tan\theta - \sin\gamma) $$
$$ = Y\omega (\cos\gamma \tan\theta - \sin\gamma) \quad \ldots\ldots (41) $$

With this substitution, and other substitutions the same as for the offset follower,

$$ \left[{}_tA_{P4} + \frac{Y\omega^2}{\cos\gamma} (\cos\gamma + \sin\gamma \tan\theta) - \frac{Y^2\omega^2}{L\cos^2\gamma} (\cos\gamma \tan\theta - \sin\gamma)^2 \tan\theta \right] \cos\theta $$
$$ = \frac{2Y\omega^2}{\cos\gamma} - \frac{Y^2\omega^2}{R\cos^2\theta} \quad \ldots\ldots (42) $$

Rearranging terms and solving for the reciprocal of R give

$$ \frac{1}{R} = \frac{2\cos\theta - (1 + \tan\gamma \tan\theta)\cos^3\theta}{Y} + \frac{\sin\theta \cos^2\theta (\tan\theta - \tan\gamma)^2}{L} - \frac{{}_tA_{P4} \cos^3\theta}{Y^2\omega^2} \quad \ldots\ldots (43) $$

If it is more convenient to work with angular acceleration of the follower, instead of the tangential component of acceleration ${}_tA_{P4}$, $L\alpha_4$ may be written in place of ${}_tA_{P4}$ in Equation 43.

Oscillating Flat-Faced Follower

Follower Motion: *Fig.* 23*a* shows a cam of known contour working with a flat-faced oscillating follower. The cam is assumed to be rotating at 1800 rpm counterclockwise. Point P_2 of the cam is in contact with point P_3 of the follower. The center of curvature of the cam in contact with the follower is located at C_2. The angular speed and angular acceleration of the follower are desired for the position shown.

Inasmuch as point C_2 remains at a fixed distance from the contact surface of the follower as long as the radius of curvature is constant, the kinematically equivalent linkage of *Fig.* 23*b* may be used for the analysis. The steps in the procedure are as follows:

Relate the velocity of two coincident points, point C_2 on link 2 and point C_3 on the follower, as shown in *Fig.* 23*a*, from

$$ V_{C2} = V_{C3} \twoheadrightarrow V_{C2C3} \quad \ldots\ldots (44) $$

where $V_{C2} = (O_2C_2)\omega_2 = 2(1800)(2\pi)/12(60) = 31.4$ ft per sec perpendicular to O_2C_2; V_{C3} is known in direction to be perpendicular to O_3C_3 but unknown in magnitude; V_{C2C3}, the relative velocity vector, is known to be parallel to the slot in *Fig.* 23*b*, but is unknown in magnitude.

The solution to the velocity equation is shown in *Fig.* 24*a*. The velocity of point C_3 scales off to 15.5 ft per sec. The angular speed of link 3 may be determined from $\omega_3 = V_{C3}/O_3C_3 = 15.5(12)/5.1 = 36.5$ rad per sec, counterclockwise.

The equation relating the acceleration of two coincident points, C_2 and C_3, is

$$ A_{C2} = A_{C3} \twoheadrightarrow {}_nA_{C2C3} \twoheadrightarrow {}_tA_{C2C3} \twoheadrightarrow {}_{cor}A_{C2C3} \quad \ldots\ldots (45) $$

where $A_{C2} = (O_2C_2)\omega_2^2 = 2[1800(2\pi)]^2/12(60)^2 = 5920$ ft per sec^2; $A_{C3} = (O_3C_3)\omega_3^2 \twoheadrightarrow (O_3C_3)\alpha_3 = 5.1(36.5)^2/12 \twoheadrightarrow (O_3C_3)\alpha_3 = 566$ ft per sec^2 $\twoheadrightarrow (O_3C_3)\alpha_3$; ${}_nA_{C2C3} = 0$; ${}_tA_{C2C3}$ is unknown in magnitude, but known in direction to be parallel to the slot; ${}_{cor}A_{C2C3} = 2(V_{C2C3})\omega_3 = 2(30.4)(36.5) = 2220$ ft per sec^2. The Coriolis component is a vector perpendicular to the relative velocity, V_{C2C3}, and directed downward to the left, as shown in *Fig.* 24*b*.

Since there are two unknowns, magnitude of $(O_3C_3)\alpha_3$ and ${}_tA_{C2C3}$, the equation may be solved. *Fig.* 24*b* shows the graphical solution. The angular acceleration of link 3 may be found from $\alpha_3 = (O_3C_3)\alpha_3/(O_3C_3) = 3130(12)/5.1 = 7360$ rad per sec^2 counterclockwise.

Radius of Curvature: *Fig.* 25*a* shows the given information for an oscillating flat-faced follower working with a cam. The cam is rotating counterclockwise at a uniform speed of 1200 rpm while the flat-faced follower is to rotate at a rate of 30 rad per sec counterclockwise with an angular acceleration of 2400 rad per sec^2 clockwise for the position shown. The problem is to determine the radius of curvature of the cam at the point of contact.

One locus for the center of curvature may be obtained from a velocity analysis, using the principle that the normal to the cam and follower at the point of contact will include the instant center of the cam and follower and the center of curvature of the cam. The instant center will lie on the line joining O_2 and O_3. If the instant center is taken at an unknown distance h, *Fig.* 25*b*, from O_2, distance h may be computed from the fact that the velocity of the instant center is the same whether the instant center be considered a point on link 2 or 3. That is,

$$ \frac{2\pi(1200)h}{12(60)} = \frac{30(h + 4.85)}{12} \quad \ldots\ldots (46) $$

where the distance between points O_2 and O_3 measures 4.85 inches. From Equation 46, $h = 1.52$ inches. The instant center, I, is located to the left of O_2 because of the direction of rotation of the cam and follower.

The line through point I perpendicular to the face of the follower determines the common normal on which the center of curvature of the cam lies.

An artifice will be used to obtain the location of the center of curvature from an acceleration analy-

sis: an inversion of the mechanism will be made, as shown in *Fig. 25c*.

The inversion is arrived at by giving each member the same motion; that is, each member is pictured as having superposed upon the original motion a clockwise angular speed of 30 rad per sec and a counterclockwise angular acceleration of 2400 rad per sec². Consequently, link 3 would be considered stationary; the frame (link 1) would be considered to be rotating clockwise at $\omega_{13} = 30$ rad per sec and accelerating counterclockwise at $\alpha_{13} = 2400$ rad per sec²; and link 2 would be considered to be rotating counterclockwise at $\omega_{23} = 95.6$ rad per sec—that is, $(40\pi - 30)$ rad per sec—and accelerating counterclockwise at $\alpha_{23} = 2400$ rad per sec².

It is to be noted that the acceleration analysis to be made gives a solution to the inverted mechanism, and does not give the accelerations for the original mechanism. The procedure of solution is given in the following paragraphs. Refer to *Fig. 25c* for the symbols used.

The acceleration of point O_2, where point O_2 is considered moving in the inverted mechanism, is

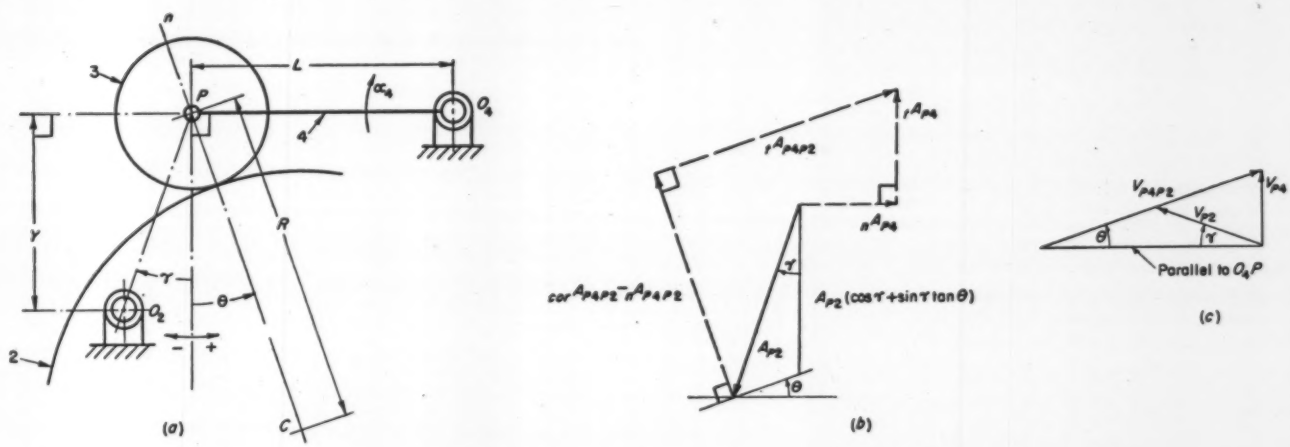
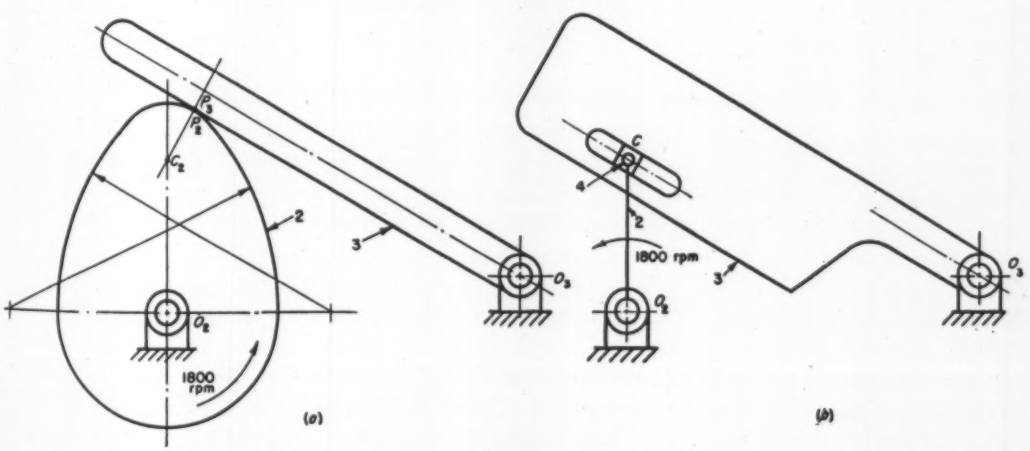


Fig. 22—At *a*, notation and geometric relationships for development of equation giving radius of curvature of cam with oscillating roller follower. Acceleration and velocity polygons, *b* and *c*, show trigonometric relationships

Fig. 23—Cam of known contour with oscillating flat-faced follower, *a*, and kinematically equivalent linkage, *b*



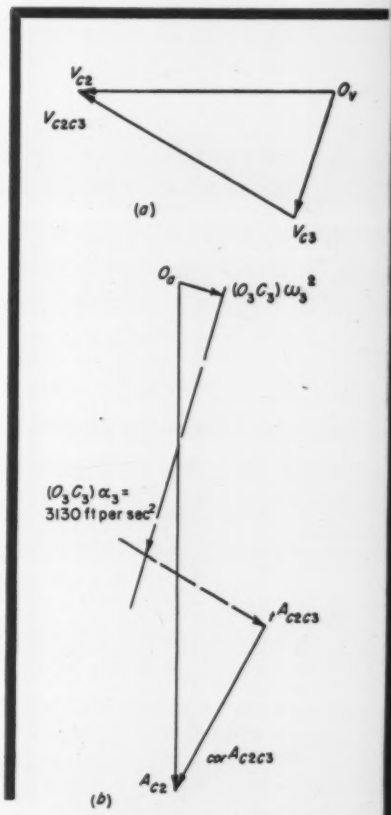


Fig. 24—Velocity polygon, *a*, and acceleration polygon, *b*, for equivalent linkage, *Fig. 23 b*

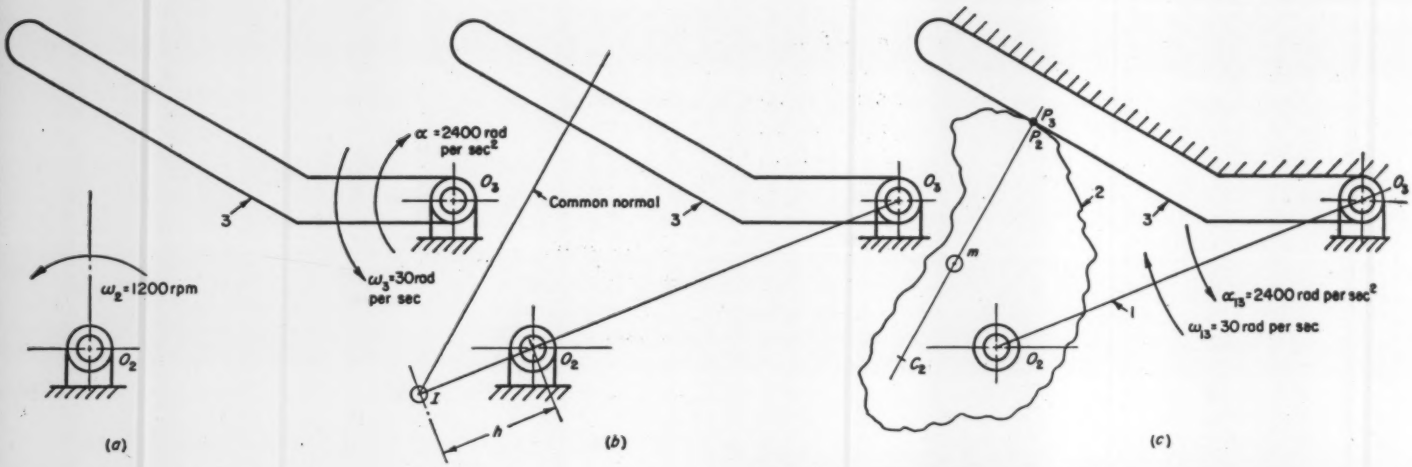
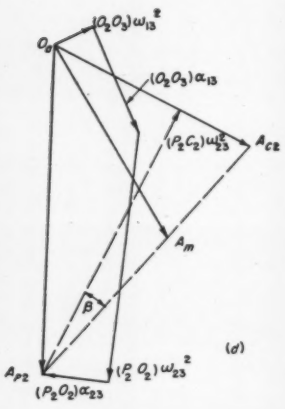


Fig. 25 — At *a*, oscillating flat-faced follower of known position and motion. Problem is to find radius of curvature of cam centered at O_2. Stages are: *b*, common normal between cam and follower, containing center of curvature, determined from velocity analysis; *c*, inverted mechanism used for acceleration analysis; and *d*, acceleration polygon for *c*



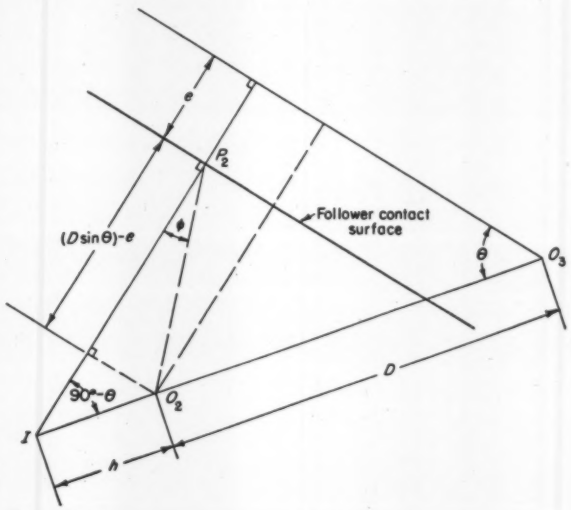


Fig. 26—Notation and geometric relationships for development of equation giving radius of curvature of cam with oscillating flat-faced follower

given by

$$A_{O2} = (O_2 O_3)\,\omega_{13}^2 \twoheadrightarrow (O_2O_3)\,\alpha_{13} \quad \ldots\ldots\ldots\ldots (47)$$

where $(O_2O_3)\omega_{13}^2 = 4.85(30)^2/12 = 364$ ft per sec², directed from O_2 to O_3; $(O_2O_3)\alpha_{13} = 4.85(2400)/12 = 970$ ft per sec², perpendicular to the line joining points O_2 and O_2.

These vectors are shown in position in the acceleration polygon of *Fig.* 25*d*.

The acceleration of point P_2, the point of the cam in contact with point P_3 of the follower, may be found from

$$A_{P2} = A_{O2} \twoheadrightarrow (P_2O_2)\omega_{23}^2 \twoheadrightarrow (P_2O_2)\alpha_{23} \quad \ldots\ldots\ldots (48)$$

where $(P_2O_2)\omega_{23}^2 = 2.8(95.6)^2/12 = 2130$ ft per sec², directed from P_2 to O_2; $(P_2O_2)\alpha_{23} = 2.8(2400)/12 = 560$ ft per sec², perpendicular to the line joining P_2 and O_2.

Since there are only two unknowns in Equation 48, the direction and magnitude of acceleration of point P_2, the equation may be solved. *Fig.* 25*d* shows A_{P2}.

The acceleration of point C_2, the center of curvautre, may be related to that of point P by

$$A_{C2} = A_{P2} \twoheadrightarrow (C_2P_2)\omega_{23}^2 \twoheadrightarrow (C_2P_2)\alpha_{23} \quad \ldots\ldots\ldots (49)$$

Up to this point, the location of point C_2 is unknown, but the acceleration of point C_2 for the inverted mechanism is known to be parallel to the face of the follower. In Equation 49 there are two unknowns: magnitude of A_{C2} and magnitude of C_2P_2. One method of solution to Equation 49 is to consider the determination of the acceleration of any arbitrary point, as point m in *Fig.* 25*c*. The acceleration of point m may be found from

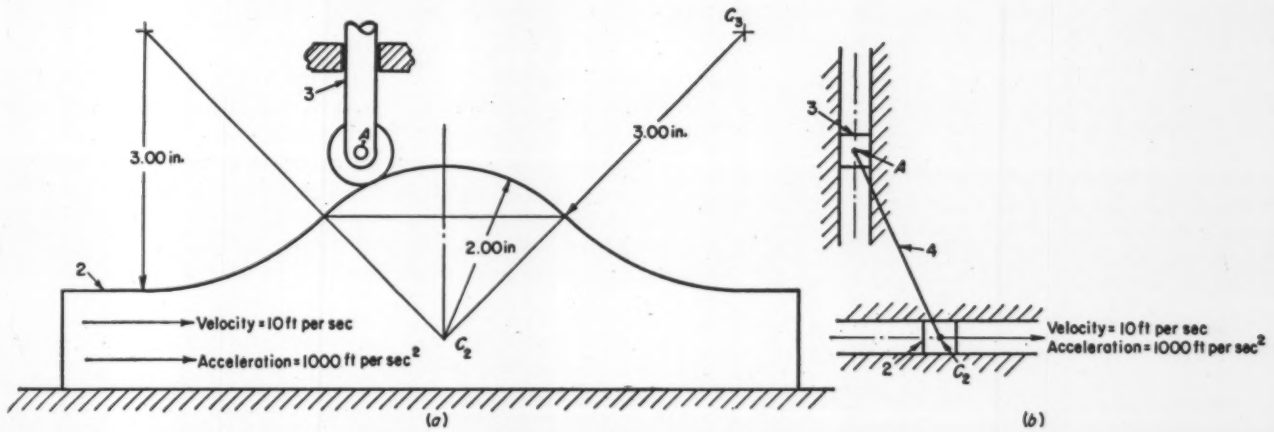
$$A_m = A_{P2} \twoheadrightarrow (m\,P_2)\omega_{23}^2 \twoheadrightarrow (m\,P_2)\alpha_{23} \quad \ldots\ldots\ldots (50)$$

where $(mP_2)\omega_{23}^2 = 2(95.6)^2/12 = 1520$ ft per sec² directed from point m to P_2; $(mP_2)\alpha_{23} = 2(2400)/12 = 400$ ft per sec² perpendicular to the line between points m and P_2. A_m and A_{C2} are shown in *Fig.* 25*d*. Note that, essentially, angle β in *Fig.* 25*d* has been found by the use of an arbitrary point m where $\tan\beta = (mP_2)\alpha_{23}/(mP_2)\omega_{23}^2 = \alpha_{23}/\omega_{23}^2$.

Vector $(C_2P_2)\omega_{23}^2$ scales off to 2520 ft per sec². Thus, $(C_2P_2)\omega_{23}^2 = 2520$ ft per sec² or $(C_2P_2)(95.6)^2 = 2520$ ft per sec². Thus, $(C_2P_2) = 0.278$ ft or 3.32 inches.

Note that the acceleration of point m need not have been determined. Inasmuch as the normal component of acceleration of point C_2 with respect

Fig. 27—Reciprocating cam of known contour with reciprocating follower, *a*, and kinematically equivalent system, *b*



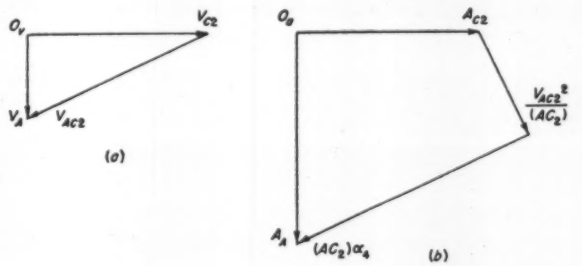


Fig. 28—Velocity polygon, *a*, and acceleration polygon, *b*, for equivalent system, *Fig.* 27*b*

to point P_2 is all that is necessary to determine the radius of curvature, it may be found directly by drawing a line from the tip of A_{P2} in the acceleration polygon to the line giving the direction of acceleration of point C_2, the line parallel to the face of the follower.

Exact Radius of Curvature: The graphical solution may be used to determine an analytical expression for the radius of curvature. *Fig.* 26 shows the geometry of the cam and oscillating flat-faced follower used in the analysis.

From *Fig.* 25*d*, by using the components of acceleration perpendicular to the contact surface of the follower, one may obtain

$$(P_2C_2)\omega_{23}^2 = -(O_2O_3)\omega_{13}^2 \sin\theta + (O_2O_3)\alpha_{13}\cos\theta + (P_2O_2)\omega_{23}^2\cos\phi + (P_2O_2)\alpha_{23}\sin\phi \quad \ldots\ldots (51)$$

From *Fig.* 26, $(P_2O_2)\sin\phi = h\sin(90-\theta)$. Also, $(P_2O_2)\cos\phi = D\sin\theta - e$. The following relationships also exist: $P_2C_2 = R$, the radius of curvature; $\omega_{23} = \omega_2 - \omega_3$; $O_2O_3 = D$; $\omega_{13} = \omega_3$ (in magnitude); $\alpha_{13} = \alpha_3$ (in magnitude); $\alpha_{23} = \alpha_3$ (in magnitude); and $h = D\omega_3/(\omega_2 - \omega_3)$. Substitution of these relationships into Equation 51 gives

$$R(\omega_2 - \omega_3)^2 = -D\omega_3^2\sin\theta + D\alpha_3\cos\theta + (D\sin\theta - e)(\omega_2 - \omega_3)^2 + \frac{D\omega_3}{\omega_2 - \omega_3}\alpha_3\cos\theta \quad \ldots\ldots (52)$$

By clearing terms, one may obtain

$$R = \frac{D}{\left(1 - \frac{\omega_3}{\omega_2}\right)^2}\left[\left(1 - 2\frac{\omega_3}{\omega_2}\right)\sin\theta + \frac{\alpha_3\cos\theta}{\omega_2^2\left(1 - \frac{\omega_3}{\omega_2}\right)}\right] - e \quad \ldots\ldots (53)$$

In Equation 53, ω_2 is considered positive if the cam is rotating counterclockwise; ω_3 is considered positive if the follower is rotating counterclockwise; α_3 is considered positive if the follower has clockwise angular acceleration.

Reciprocating Roller Follower With Reciprocating Cam

Follower Motion: *Fig.* 27*a* shows a reciprocating cam of known contour moving with a known velocity of 10 ft per sec and a known acceleration of 1000 ft per sec² for the position shown. Desired are the velocity and acceleration of the reciprocating roller follower for the position shown. The follower is shown in position where the cam radius of curvature is 2.00 inches, with the center of curvature at C_2.

Use of a kinematically equivalent system simplifies the procedure of attack. *Fig.* 27*b* shows such a system where a pin is pictured as being introduced at C_2, link 4 introduced, and a slider introduced to have point C_2 move as in the original mechanism.

So long as the radius of curvature is constant, the distance between points A and C_2 in *Fig. 27b* will be the same as the distance between A and C_2 in *Fig. 27a*.

The velocity and acceleration analysis for the mechanism will be made, then, with reference to *Fig. 27b*. *Fig. 28a* shows the vector solution for the velocity equation:

$$V_A = V_{C2} \twoheadrightarrow V_{AC2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (54)$$

where V_A is the velocity of the follower, known in direction but unknown in magnitude; V_{C2} = 10 ft per sec, the velocity of the cam, known completely; V_{AC2} is the relative velocity of point A of the follower with respect to the center of curvature of the cam, point C_2, where the relative velocity is known in direction to be perpendicular to the line joining A and C_2. The velocity of point A, V_A, scales off to 4.5 ft per sec, downward.

Fig. 28b shows the solution to the acceleration equation for two points on a rigid link, points A and C_2 on link 4:

$$A_A = A_{C2} \twoheadrightarrow \frac{V_{AC2}^2}{(AC_2)} \twoheadrightarrow (AC_2)\,\alpha_4 \quad \ldots\ldots\ldots\ldots (55)$$

where A_A is the acceleration of the follower, unknown in magnitude but known in direction; A_{C2} = 1000 ft per sec², the known acceleration of the cam; $V_{AC2}^2/(AC_2) = (11)^2 12/2.38 = 610$ ft per sec² (This is the normal acceleration of point A with respect to point C_2 of link 4, directed from A to C_2, a completely known vector); $(AC_2)\alpha_4$ is the relative tangential acceleration of point A with respect to point C_2 (This vector is unknown in magnitude, but known in direction to be perpendicular to the line joining A and C_2).

Thus, with only two unknowns, magnitude of A_A and magnitude of $(AC_2)\alpha_4$, the vector equation is soluble. A_A scales off to 1140 ft per sec², downward.

Radius of Curvature: *Fig. 29a* shows the system to be analyzed for determination of the center of curvature and radius of curvature of a cam for a prescribed motion of the cam and for a prescribed motion of the follower at a given position of the follower. The velocity of the cam is taken as 8 ft per sec to the right, and the acceleration of the cam is taken as 500 ft per sec² to the right. The follower is to move with a velocity of 6 ft per sec upward, and is to have an acceleration of 1200 ft per sec² upward for the position shown.

Again, a kinematically equivalent system will be used, as in the preceding analysis. The equivalent system cannot be drawn in position because the center of curvature of the cam is not known. It is known that the system will be comparable to that shown in *Fig. 27b*, and such a system must be kept in mind during the analysis.

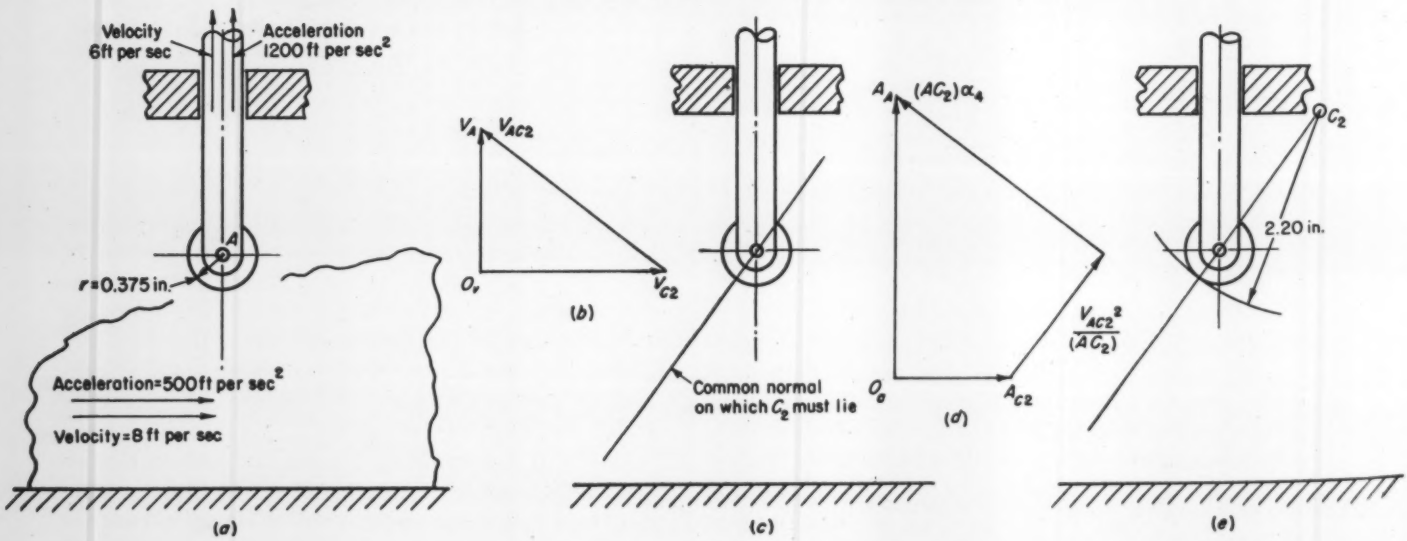
The first step in the solution is to determine the line on which the center of curvature must lie from a velocity analysis. The velocity of point A the center of the roller, and the velocity of point C_2, the center of curvature of the cam at the point of contact, can be expressed by the following equation, even though the location of point C_2 is not known;

$$V_A = V_{C2} \twoheadrightarrow V_{AC2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (56)$$

where V_A is known, 6 ft per sec upward; V_{C2} is known, 8 ft per sec to the right; V_{AC2} is unknown in direction and magnitude.

Since there are only two unknowns, the equation

Fig. 29—Reciprocating roller follower, of known position and motion, and reciprocating cam. Stages in finding cam radius of curvature are: *b*, velocity polygon; *c*, common normal between cam and follower, determined from velocity solution; *d*, acceleration polygon; and *e*, center of curvature located



can be solved. The solution is shown in *Fig. 29b*. V_{AC2} scales off to 10 ft per sec. Since V_{AC2} is perpendicular to the line between points A and C_2, the direction of this line can be found, as shown in *Fig. 29c*.

The next step is to express the relation of the acceleration of two points A and C_2 on a rigid link:

$$A_A = A_{C2} \twoheadrightarrow \frac{V_{AC2}^2}{(AC_2)} \twoheadrightarrow (AC_2)\alpha_4 \quad \ldots\ldots\ldots\ldots (57)$$

where A_A, the acceleration of the follower, is 1200 ft per sec² upward; A_{C2}, the acceleration of the cam, is 500 ft per sec² to the right; V_{AC2}^2/AC_2, the relative normal acceleration of point A with respect to point C_2 is unknown in magnitude, but known in direction—along the line perpendicular to the relative velocity; $(AC_2)\alpha_4$, the relative tangential acceleration of point A with respect to point C_2, is unknown in magnitude but known in direction—perpendicular to the relative normal acceleration.

The graphical solution to the vector equation is shown in *Fig. 29d* where the relative normal and tangential acceleration components are determined in magnitude.

The relative normal component is the vector necessary to the determination of the radius of curvature. The normal acceleration scales off to 660 ft per sec². The distance from A to C_2 may be calculated from ${}_nA_{AC2} = V_{AC2}^2/(AC_2) = 660 = (10.0)^2/(AC_2)$. Thus $AC_2 = 0.152$ ft or 1.82 inches.

The radius of the roller must be taken into account in determining the radius of curvature. Whether the radius of the roller should be added to or subtracted from AC_2 depends on the location of point C_2, which in turn depends on the direction of $V_{AC2}^2/(AC_2)$.

The direction of this normal component of acceleration, as determined in *Fig. 29d*, shows that the center of curvature is outside the cam; or, for this case, the radius of the roller r should be added to AC_2 to determine the radius of curvature R. That is, $R = AC_2 + r = 1.82 + 0.375 = 2.20$ inches.

Fig. 29e shows the center of curvature to satisfy all the conditions.

Exact Radius of Curvature: The determination of an analytical expression for the radius of curvature can be obtained from the velocity and acceleration analyses with, of course, as much accuracy as desired in the final result, although the graphical solution gives sufficient accuracy for most problems.

The velocity analysis will give the line on which the center of curvature lies; or, expressed differently, the angle of the pressure line may be found from the velocity analysis. *Figs. 30a* and *b* may be used to determine the pressure angle ϕ:

$$\tan\phi = \frac{V_A}{V_{C2}} \quad \ldots\ldots\ldots\ldots (58)$$

The relative velocity may be expressed analytically by

$$V_{AC2} = \frac{V_{C2}}{\cos\phi} \quad \ldots\ldots\ldots\ldots (59)$$

The distance pr in *Fig. 30c*, the acceleration polygon, can be expressed by

$$\tan\phi = \frac{(pr)}{A_{C2}} \quad \ldots\ldots\ldots\ldots (60)$$

From Equations 58 and 60,

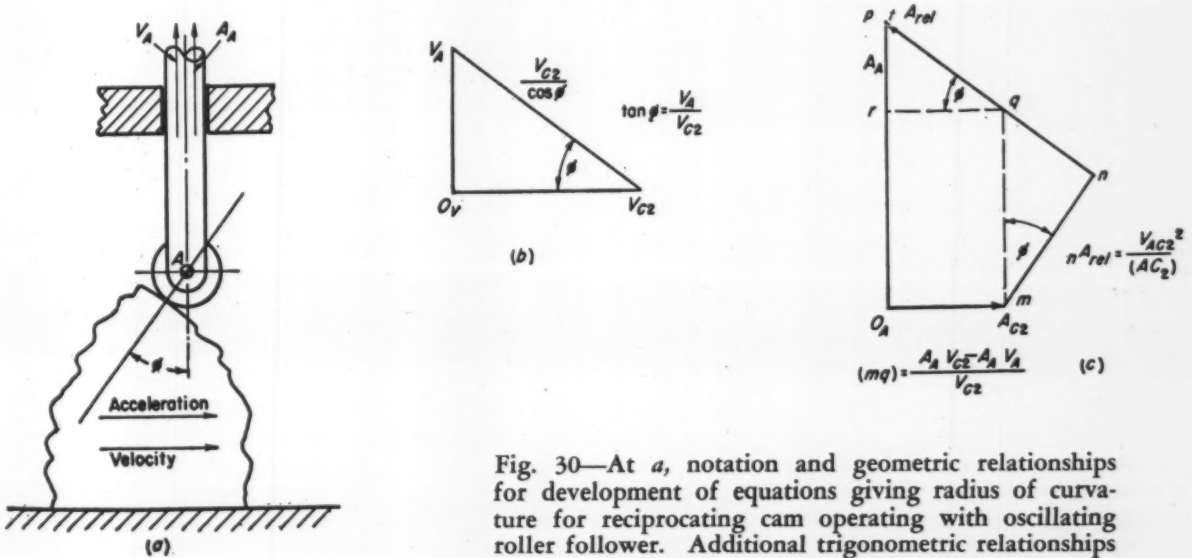


Fig. 30—At *a*, notation and geometric relationships for development of equations giving radius of curvature for reciprocating cam operating with oscillating roller follower. Additional trigonometric relationships are shown by velocity and acceleration polygons *b* and *c*

$$(pr) = A_{C2}\frac{V_A}{V_{c2}} \quad \ldots\ldots (61)$$

The distance mq in *Fig.* 30*c* may be expressed by

$$(mq) = A_A - (pr)$$
$$= A_A - A_{C2}\frac{V_A}{V_{C2}}$$
$$= \frac{A_A V_{C2} - A_{C2} V_A}{V_{C2}} \quad \ldots\ldots (62)$$

For triangle mnq,

$$\cos \phi = \frac{\frac{V_{AC2}^2}{(AC_2)}}{\frac{A_A V_{C2} - A_{C2} V_A}{V_{C2}}} \quad \ldots\ldots (63)$$

From Equations 59 and 63,

$$(AC_2) = \frac{V_{AC2}^3}{A_A V_{C2} - A_{C2} V_A} \quad \ldots\ldots (64)$$

Since $V_{AC2}^2 = V_A^2 + V_{C2}^2$ and since the radius of curvature R is the sum of AC_2 and the radius of the roller r,

$$R = (AC_2) + r$$
$$= \frac{(V_A^2 + V_{C2}^2)^{3/2}}{A_A V_{C2} - A_{C2} V_A} + r \quad \ldots\ldots (65)$$

In Equation 65, a velocity of the cam to the right, a velocity of the follower upward, an acceleration of the cam to the right, and an acceleration of the follower upward are to be considered positive. If the radius of curvature is positive, the center of curvature is outside the cam; if the radius of curvature is negative, the center of curvature will lie in the cam.

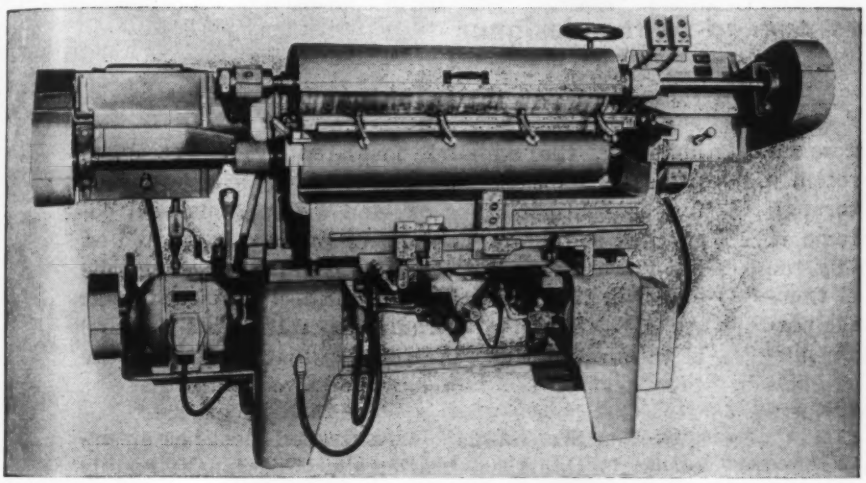
CONTEMPORARY DESIGN

Flight Recorder Withstands 2000 F Temperatures

A FLIGHT recorder using 1 mil thick aluminum tape for recording will withstand 2000 F temperatures resulting from open fire for ½-hour without destruction of the record. Indicating air speed, altitude, vertical acceleration and flight direction by means of stylus recording on the tape, the recorder operates for 300 hours. The fireproof case is double walled; the outside wall is zinc-plated mild steel, the inside wall is aluminum, with a layer of Perlite insulation between.

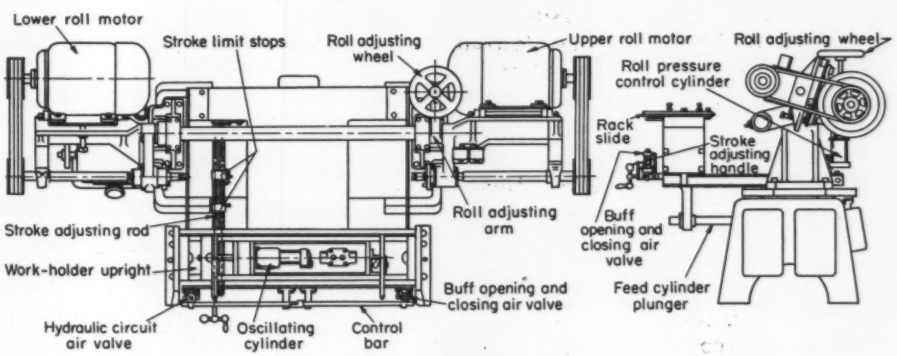
A 28-volt motor and power spring drives an escapement mechanism which controls speed of the chart takeup drive. Following power source failure the recorder developed by General Mills Inc. will continue to operate for 10 minutes on the spring drive alone. The record will withstand 36 hours immersion in a sea water, and the instrument withstands salt-spray and humidity tests.

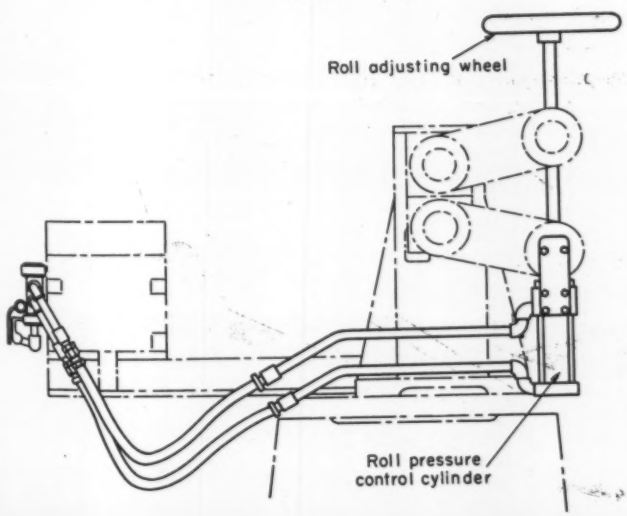
Automatic Roll Float in Surface Finishing Machine



A COMPRESSED air circuit, which opens and closes buffing or polishing rolls for unloading, also provides automatic roll float in the model 202-A surface finishing machine of Clair Mfg. Co. Inc. Thus uniform roll pressure is provided as the rolls follow irregular contours of wrenches, cutlery, surgical instruments or other pieces being finished. By using rolls of the proper density and adjusting roll pressure, any degree of finish from flash removal to mirror finish can be produced.

Rolls, 40 inches in width and with diameters ranging from 4 to 9 inches, are rotated in opposite directions by separate 7½-horsepower motors, while a third 2-horsepower motor provides power for the hydraulic pump. Workpieces, preloaded on a rack, are fed into the rolls and oscillated sideways by hydraulic cylinders. Feed stroke is adjustable from ¾ to 14 inches by means of limit stops which trip the saddle pilot valve. Side-to-side oscillation is adjustable from ½ to 1¾ inches. A safety control bar stops feed-in and oscillation and causes the rolls to open if depressed by light body pressure.





Primary adjustment for work thickness is controlled by handwheel adjustment of the air-cylinder float assembly. The cylinder is swiveled onto the bottom roll adjusting arm, and the cylinder piston rod is threaded through a swivel in the top roll adjusting arm. These arms are geared together. By adjusting the handwheel, and consequently the relative position of the upper roll arm on the piston rod, the piston serves as a limit stop when it either "bottoms" or "tops" in the cylinder. Plant line air pressure is regulated to determine pressure in an accumulator connected to the cylinder. Thus, contact roll pressure can be maintained despite varying workpiece contour.

Steel Extrusions

PRODUCTION AND DESIGN

Using the French Ugine-Sejournet process for hot extruding steel sections, new opportunities are opened to the designer

EXTRUSION of nonferrous alloys is a process familiar to most designers. But until recently no one could successfully squeeze steel through dies. Now these difficulties have been overcome in a revolutionary new process being pioneered by the National Tube Division of United States Steel Company. The "big squeeze" of steel has been made possible by use of a glass "cake," aided for certain purposes by a knitted glass fiber "stocking." The glass serves both as a lubricant and as an insulator, permitting the steel to pass neatly through dies.

Solid Sections: Extrusion can be either in the form of tubes or solid sections. The steel to be extruded is in the form of a "slug," which is a section cut from a solid rolled bar. After the slug has been heated to the proper temperature, it is inserted in the extruding press. Previously placed in the press, in a position next to the die, is the glass cake.

As the press ram is set in motion, smooth, even squeezing pressure causes the glass cake to flow and form a coating which spreads over the front of the slug. As the ram presses forward, the steel enters and passes through the die, forming a solid section the shape of the die. A film of glass clings to the surface of the steel insulating the die from the heat of the steel. At the end of the extruding operation, the end of the extruded section next to the ram is sawed off.

Extruded Tubes: If a tube is to be extruded, the mandrel extending from the end of the ram is covered with the glass fiber stocking and has a piercer cap mounted on the end. As the ram is moved forward, forcing the piercer cap into the center of the hot slug, the mandrel, insulated by the stocking, passes through the steel. The piercer cap is pushed forward until it drops off, and with the mandrel positioned in the die, pressure of the ram is exerted on the pierced steel, forcing the metal through the die and over the mandrel in the form of a finished tube. At the end of the extruding operation, the mandrel is withdrawn inside the ram, so that the end of the tube next to the ram may be sawed off.

Section Size Range: All extruded steel has an exceedingly thin glass coating, but this can be readily removed by pickling or sand blasting. Any bending, twisting or camber in the extruded steel is removed by stretch-straightening and detwisting machines.

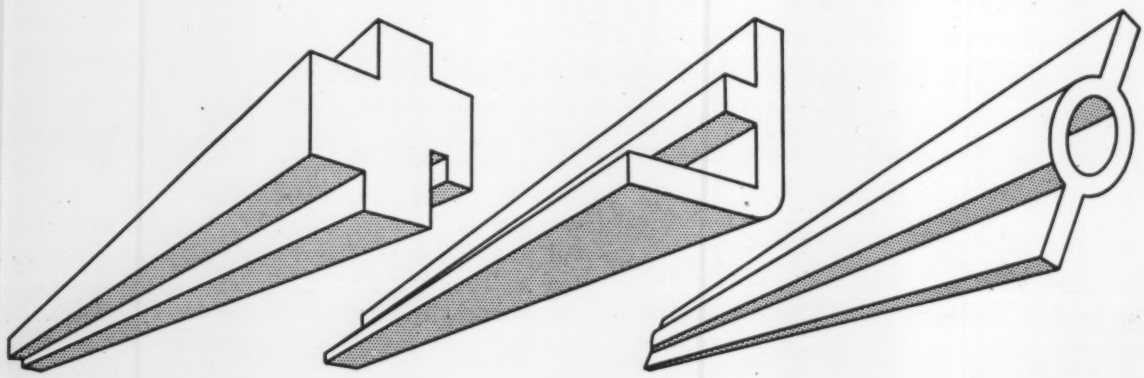
Hollow sections can be hot-extruded in outside diameters ranging from a maximum of 5⅛ inches to a minimum of 1 5/16 inches, with wall thicknesses ranging from ½-inch down to about 1/10-inch.

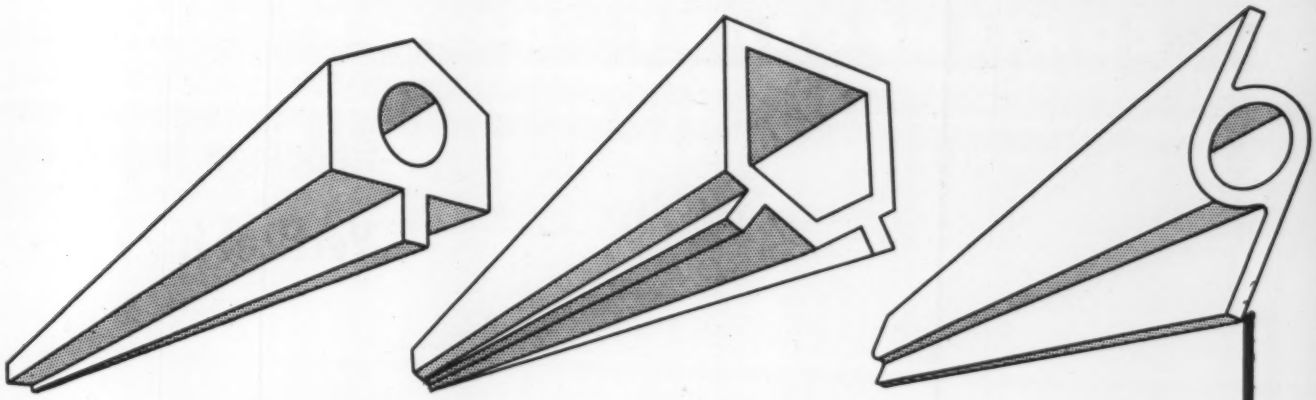
Solid sections can be extruded into almost any shape desired within the following limitations: The area of the end of the section must not exceed 5½ square inches or fall below ½-square inch, and the section must fit within a circle of 5⅛ inches in diameter. The smallest flat bars that can be extruded are ⅜-inch thick by ¾-inch wide.

It may be found possible to produce a greater range of sizes as experience is gained. Other presses can be built, if demand justifies it, to extrude larger or smaller sections.

Variety of Shapes: Hot extrusion of steel has many advantages. It makes possible production of an almost endless variety of shapes. When desired, sharp corners and angles can be produced—much sharper than can be obtained by rolling steel. Shapes

Article, courtesy *U. S. Steel News*

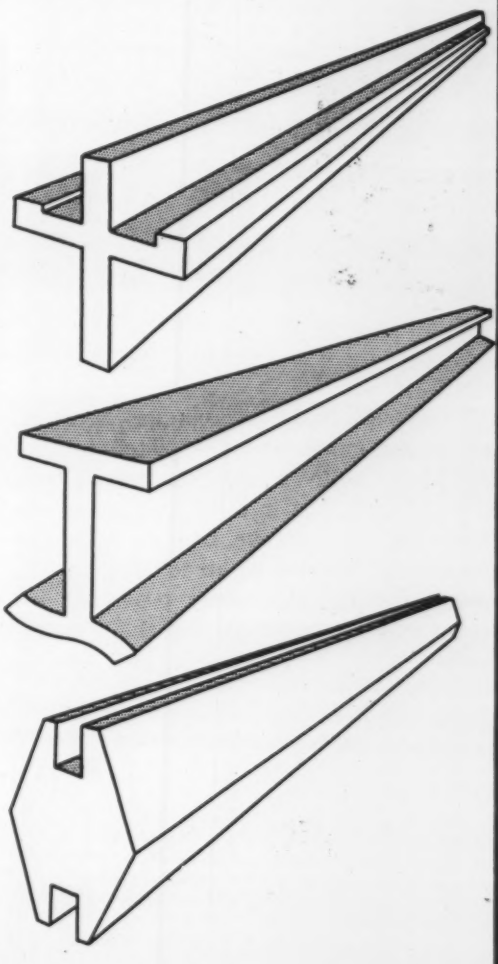




can be made closely approaching those desired in the end use of the product with the result that subsequent machining is sharply reduced or made entirely unnecessary.

Since dies can be changed quickly and simply, the extrusion press is more flexible than a rolling mill when a variety of shapes must be produced. Perhaps the most interesting advantage of extrusion is that it can produce sections that cannot be rolled at all—sections that have heretofore been made, if they have been produced at all, by high-cost machining operations or by welding parts together.

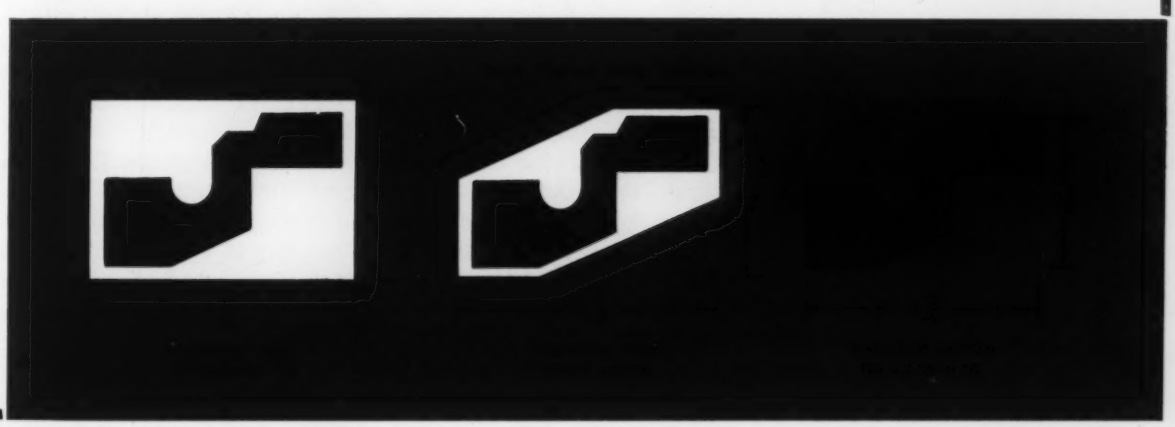
A striking example of a shape that cannot be rolled is the tank ring section in the illustration below. This section is used in making the ball bearing race for an Army tank turret. The special extruded shape eliminates the machining necessary when the same shape is made from a rolled bar.

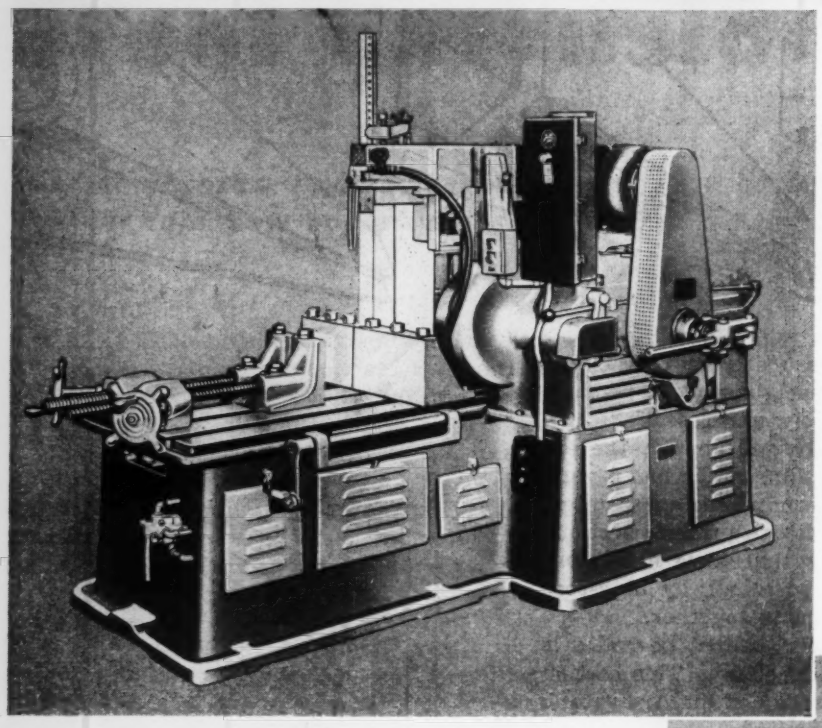


Materials: The hot extrusion process has the further advantage that it can be used with types of steel that are difficult or impossible to roll or pierce. Steels that can be extruded include stainless steels and special superalloy steels, as well as the ordinary alloy and carbon steels.

The nature of the process makes it possible to improve surface finish and other quality factors. But, in cases where more accurate dimensions, sharper corners or better finish than can be obtained with hot extrusion are desired, the extruded section can be cold drawn. This single cold-drawing operation is justified when it eliminates finish machining that would otherwise be required.

Future Aspects: Of the many interesting possibilities with extruded steel none has greater appeal than the opportunity it opens up for new engineering and design concepts. Since limitations on the shapes of rolled sections have been so largely removed and the cost of dies is comparatively low, new sections can be developed to fit the particular needs.

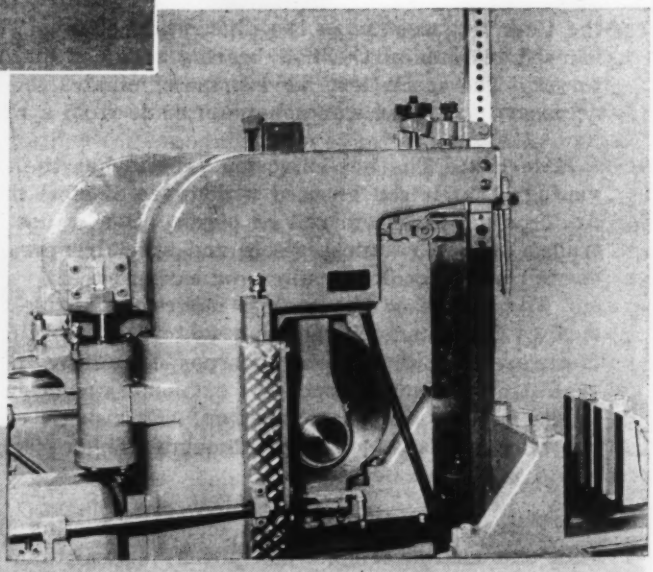


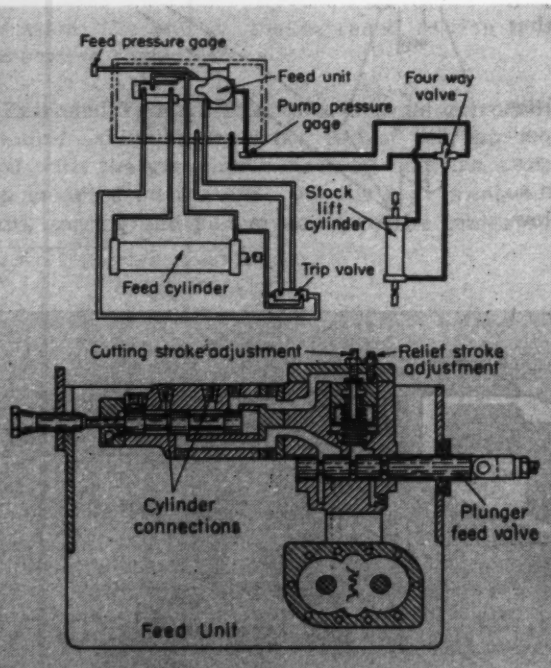


Redesign Improves Vertical Hack Saw

SEVERAL design changes in the 18 by 18 inch hack saw machine of Peerless Machine Co. have been incorporated to improve smoothness of operation and rate of cutting. Now included is an air cylinder counterbalance and an improved hydraulic system. As a result, timing of the feed action to bring the saw blade in and out of the work is improved, and sawing speeds up to 10 square inches per minute are now possible.

The counterbalance cylinder is attached to the saw frame guide, and the piston to the saw frame. The upper cylinder head is ported to provide free air entry; the lower head has an intake and safety valve. On the upstroke, free air exhaust is permitted, and on the downstroke air is compressed and metered out of the cylinder—thus providing a "cushioned" action that counterbalances the weight of the saw frame.





Two basic mechanisms are operated by the hydraulic circuit; a stock lift mechanism and feed system. The stock lift cylinder operates two eccentric rollers, one on each side of the work table, which are elevated when feeding the work across the table. The feed unit controls a two-way hydraulic cylinder which feeds the work and provides relief on the noncutting stroke. A plunger feed valve with ½-inch travel controls cylinder movement. One adjusting screw limits the opening of a poppet valve, thus metering a predetermined amount of oil on the cutting stroke, while the other controls rate of feed movement on the relief stroke. An adjusting valve which controls feed pressure applied on the blade, and a pump-pressure adjusting valve, are also included in the circuit.

design properties of materials 2

strength in tension

How tensile strength data from standard property tests can be used more effectively in design

By Robert L. Stedfeld
Associate Editor, Machine Design

ACTUAL LOADING of a machine part can seldom be resolved into simple unidirectional stresses. Consequently the prediction of actual part performance from theoretical loading considerations and knowledge of conventional strength "properties" data is at best an approximation. The margin for error, however, can be reduced by careful attention to the implications of the various strength properties.

Strength in tension is perhaps the most widely used type of strength data, being employed not only to supply numerical strength values, but also as a comparative indicator of strengths of various materials. Here again, caution is necessary, since compression, torsion, shear or flexural strength may actually be a better indicator for the particular design. Additionally, different materials are not always evaluated on the same basis—tension strength values reported for one material may not have the same meaning as similar values reported for another. Condition (cold-rolled, heat-treated, etc.) has a large influence on the value reported, as do section size, variations between lots and other effects.

Some of these considerations will be discussed in this article, along with a summary of the main tensile properties for representative engineering materials. Tensile strength and various other strength properties of materials will also be considered further in future articles.

Characteristic Stress-Strain Curves: As pointed out in many engineering texts, most materials can be classified into one of three groups: ductile, brittle or elastomeric, as shown in *Fig.* 1. A ductile material, *Fig.* 1*a*, has a stress-strain curve composed essentially of an elastic portion, in which the stress-strain curve follows Hooke's law, and a "plastic" portion where the curve deviates from a constant stress-to-strain relationship. Some ductile materials, such as mild steel, have definite yield points. Most, however, show only a relatively sharp "bend" where the material enters the plastic region, without a definite reversal in slope of the stress-strain curve. The main distinguishing features of the curve are the large "hump" and the difference in strain or elongation between the tensile strength and breaking strength.

Brittle materials usually have a curve similar to *Fig.* 1*b*. Generally, the distinction between brittle and ductile materials is the tensile strain at rupture; metals with a total elongation greater than 0.05-inch per inch (5 per cent elongation), for instance, are considered to be ductile. The curve

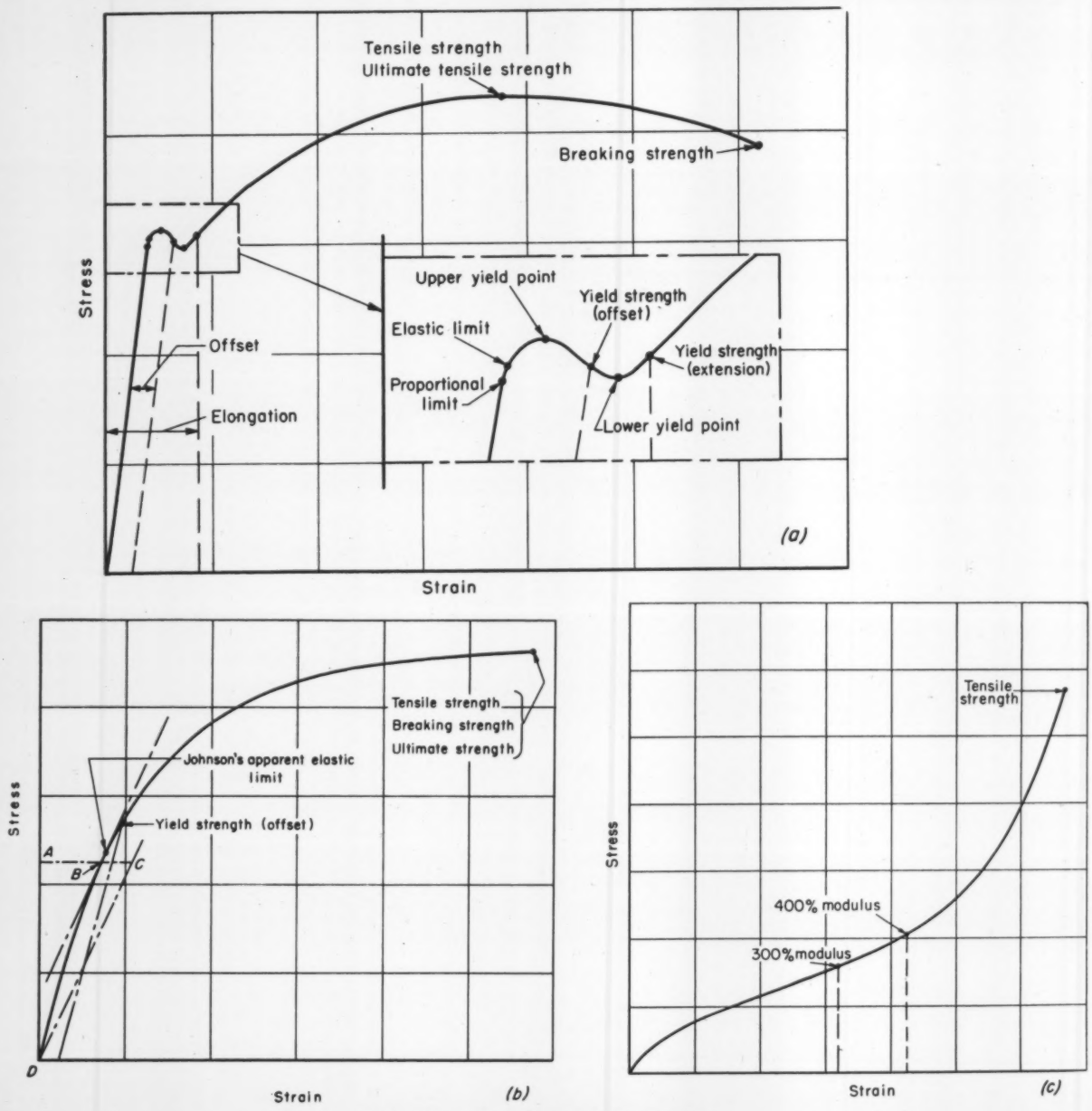


Fig. 1—Definitions for Strength in Tension

Drawings *a*, *b* and *c* represent stress-strain curves for three different types of materials based on original cross-sectional area of the test piece. Ductile materials such as mild steel are typified by *a*, although for many ductile materials the sharply defined yield points are missing. Brittle materials, such as cast iron, have curves similar to *b*; with brittle plastics and glass, however, the "tail" of the curve may be much shorter. Nonmetallic ductile materials or elastomers, such as rubber or some plastics, have curves similar to *c*. Terms used to show strength values on these curves are:

Proportional Limit is the greatest stress (unit stress)—specimen load divided by original area—which the material is capable of developing without deviating from the proportionality of stress to strain (Hooke's law).

Elastic Limit is the greatest stress which a material is capable of developing without permanent deformation remaining upon complete release of stress. In practice, elastic limit and proportional limit are usually so little different that they are often considered as a single value, sometimes called the "proportional elastic limit."

Upper and Lower Yield Points are values of stress at which a marked increase in strain occurs without corresponding increase in stress. If the stress-strain diagram does not actually become horizontal or does not show a drop in stress with increase in strain in the yield region (for instance, drawings *b* and *c*), the term "yield point" should not be used. If "yield point" alone is specified, it usually denotes the upper yield point.

Proof Stress is sometimes used instead of proportional or elastic limit. It is the yield strength at 0.01 or 0.02 per cent offset.

Yield Strength (offset) is the stress at which a material exhibits a specified limiting permanent set. Offset yield strength is often specified as "yield strength, 0.2 per cent offset" or "yield strength (offset=0.2 per cent)," and if no percentage value is given, 0.2 per cent is usually presumed. Other values which are sometimes used are 0.1 and 1 per cent.

Yield Strength (extension) is the stress at a specified elongation. Used mostly for copper-base alloys, it is usually specified as "yield strength at 0.5 per cent elongation," and is approximately equivalent to 0.35 per cent offset for these alloys.

Modulus (not to be confused with modulus of elasticity) is defined as the stress required to produce a given strain. Used exclusively for rubber and other elastomeric materials, modulus is often specified as "300 per cent modulus" or "400 per cent modulus" to denote 300 and 400 per cent elongations respectively.

Johnson's Apparent Elastic Limit, little used today, is the stress value for which the rate of change of strain with respect to stress is 50 per cent greater than at the initial straight part of the curve. In determining this limit line *AC* is drawn, as in drawing *b*. *BC* is drawn equal to ½ *AB*. A line parallel to *DC* tangent to the stress-strain curve defines Johnson's apparent elastic limit.

Useful Limit Point, a variation of Johnson's elastic limit, is found the **same way, except that *BC* on drawing** *b* is scaled off equal to *AB*.

Tensile Strength or ultimate tensile strength is the maximum tensile stress which a material is capable of developing. In brittle materials or elastomers, tensile strength is usually equal to the breaking strength.

Breaking Strength is the stress value at fracture.

True Stress is any stress value reported on the basis of actual rather than original area of the specimen.

of *Fig.* 1*b*, however, may be representative of materials normally considered as brittle but which have larger elongations than called for by this criterion. For most materials with a curve of this shape, such as gray cast iron or austenitic alloy steels, there is no true elastic region; the elastic portion of the curve is slightly curved—and even for ductile materials there is some question whether highly accurate measurements might not show deviations from Hooke's law. The "tail" of the curve (roughly from the yield strength upward) may be shortened or missing entirely for very brittle materials. Laminated plastics, for instance, have almost no elongation, and consequently the stress-strain curve becomes practically a straight line.

Stress-strain curves for elastomeric or soft materials resemble *Fig.* 1*c*. Soft rubber and plastics such as vinyl chloride, nylon and polyethylene are typical examples.

Meanings of Tensile Strength Properties: Two points on the tension stress-strain curve are of significance, and the standard ways of expressing strength in tension are aimed at defining one of these two points.

The first may be called the yield region, where the material ceases to behave elastically and starts to "flow." If the material is strained beyond this point, a certain amount of permanent set (or elongation) remains upon release of stress, so if the part must remain undeformed, tensile stresses must be lower than the limiting stress in the yield region. The second point may be considered as the highest or maximum stress the material can endure in practice. At stresses higher than this value, the parts will break.

Proportional and elastic limits, yield point, yield strength, proof stress, Johnson's apparent elastic limit and useful limit point are devices aimed at defining the first of these two values—the yield region. By definition, the elastic limit or proportional limit are the exact values desired; they are, however, difficult to determine experimentally. Johnson's apparent elastic limit and the useful limit point have the same disadvantages; the intersection of the tangent line with the stress-strain curve is hard to locate. Consequently, the yield point or yield strength (either at 0.2 per cent offset or 0.5 per cent elongation) are most often used in defining the material's departure from elastic behavior.

Tensile strength or breaking strength define the second of these two points. Ultimate tensile strength provides some measure of the reserve strength capacity of the material—its ability to stay in one piece after an overstress. Since designed parts usually become functionally inoperative if deformed, tensile strength has very little significant meaning in most design situations. Some measure of yield strength is a far better criterion. A knowl-

A gain in specified minimum tensile strength was obtained in this aircraft fuselage structural part by changing from type 301 to a 17-7 precipitation-hardening stainless. The half-hard temper 301 had a minimum specified yield strength in tension of 110,000 psi, compared with 165,000 psi minimum for the Armco 17-7 PH. Ultimate tensile strength of the finished part was increased from 150,000 to 185,000 psi minimum. Instead of being worked in the half-hard condition, the 17-7 PH stainless is worked fully annealed and is hardened by heat treatment after fabrication.

Photo, courtesy Armco Steel Corp.

edge of the tensile strength and of the ratio between yield and tensile strengths may be of value, however, where the material must be cold-formed or stretched in processing, or in housings and similar parts where the component can be used despite deformation. Tensile strength also has some value in setting up easily tested minimum specifications or standards, since in any one material, if tensile strengths are comparable, other strength properties in tension can be expected to be reasonably equivalent.

TESTING VARIATIONS: Reported strength values can be influenced highly by rate of application of strain in the testing machine, sometimes as much

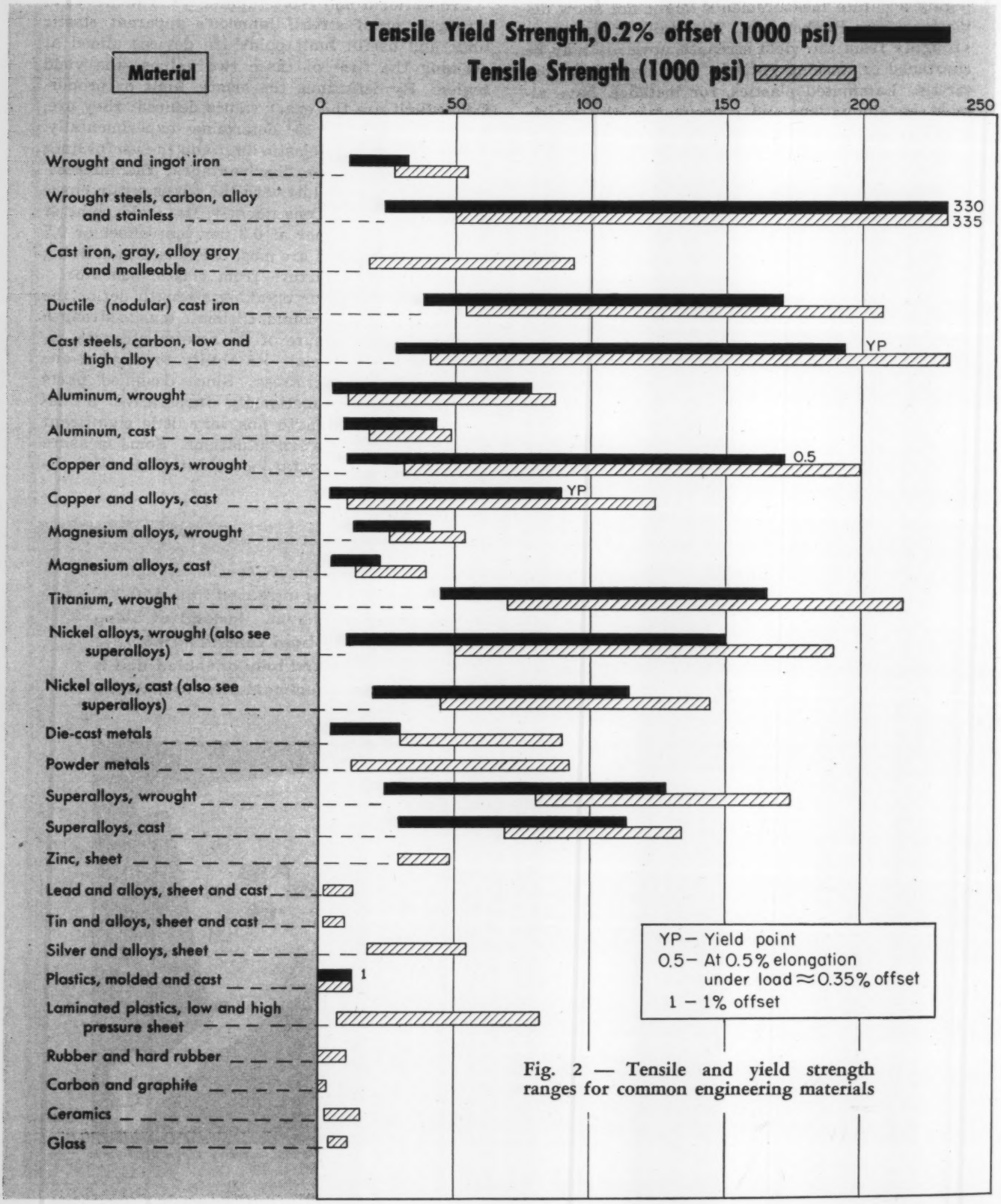


Fig. 2 — Tensile and yield strength ranges for common engineering materials

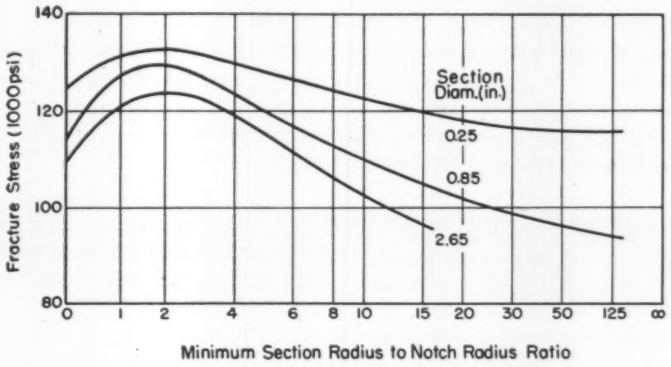


Fig. 3—Effect of varying section size and notch sharpness on the tensile strength properties of a single material, an SAE 1025 silicon-killed steel

as 10 per cent. Machine and test inaccuracies can also account for small variations. But generally, since standard test methods are followed and these factors are controlled, variations from this source are small. Some of the standard test methods and sizes of specimens for representative engineering materials are covered by the American Society for Testing Materials' specifications listed in TABLE 1.

Factors Influencing Strength in Tension: Ranges of tensile and yield strengths for broad classes of engineering materials are given in *Fig.* 2. The ranges noted are for medium-section specimens (bars, plate, sheet, etc.) in annealed through heat-treated or cold-worked conditions, and thus show extremes for each type of material. A subsequent article will detail tensile strength values for subclassifications of each group. Tensile test specimens are particular samples of the material, limited in size, shape and composition. They cannot, therefore, always be accepted as truly representative of strength in tension of the material in actual service.

Usual handbook values are given for longitudinal (not transverse) specimens of cold-worked metals, for relatively small, through-quenched specimens of heat-treated steels, and for fully fed specimens of cast metal. Values determined for one thickness of a material will usually not be representative

Table 1—Typical ASTM Specifications for Tension Testing*

Material	Specification
General	
Definitions of terms	E6-36
Metals	
Metallic materials	E8-52T
Steel products	A370-53T
Structural steel	A359-52T
Steel bars	A330-51T
Steel spring wire	A318-48T
Gray iron castings	A48-48
Malleable iron castings	A47-52
Copper-base alloys for sand castings	B208-49T
Nonmetallic materials	
Vulcanized rubber	D412-51T
Hard rubber	D530-50T
Plastics	D638-52T
Thin plastic sheets and films	D882-49T
Molded electrical insulating materials	D651-48
Electrical porcelain	D116-44

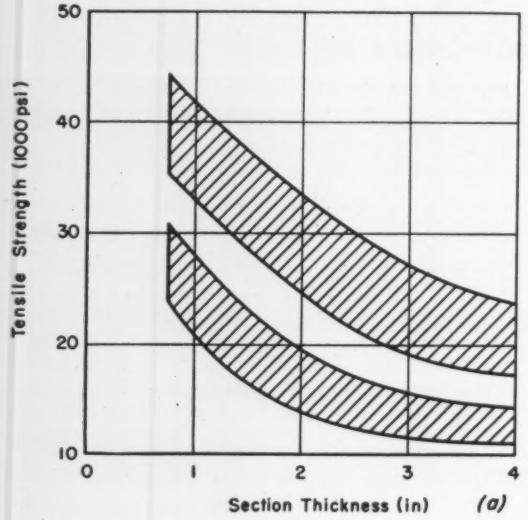
*Room-temperature. Particular ASTM specifications and standards should be consulted for each material since procedures vary.

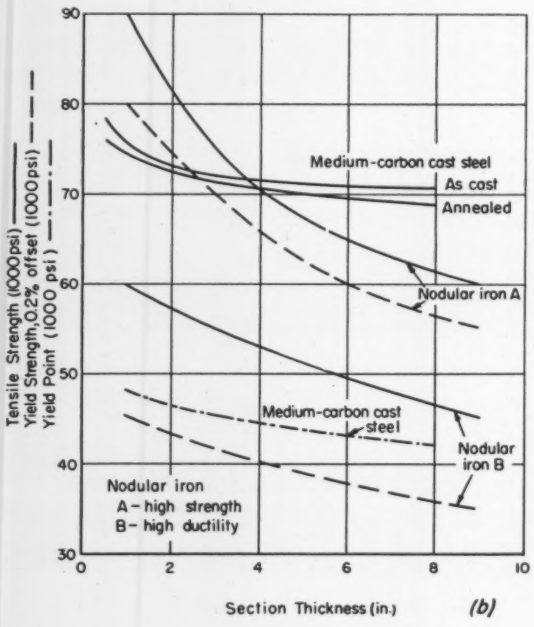
Photo, courtesy Bakelite Div., Union Carbide and Carbon Corp.

Engine cowling for this target plane is made of laminated polyester glass-fiber plastic. Structural strength was necessary, but the original aluminum cowling required 11 parts, riveted together. The revised design provided substantial strength, and only four parts are needed for the complete assembly.

of other thicknesses. Strength in one direction may not be the same as strength in another. And values reported for small fully hardened specimens of heat-treated steel will probably not be representative of larger sections, since the interior of the larger section may be slack-quenched.

Some of these factors affect tensile strength in a predictable way; others are rather difficult to evaluate. But in most cases some adjustment can





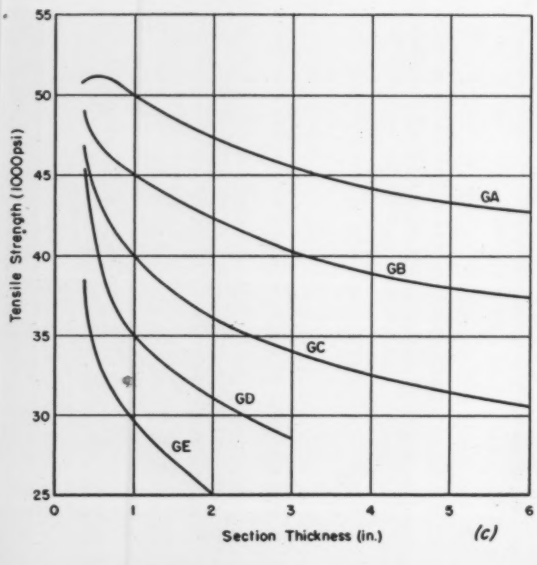
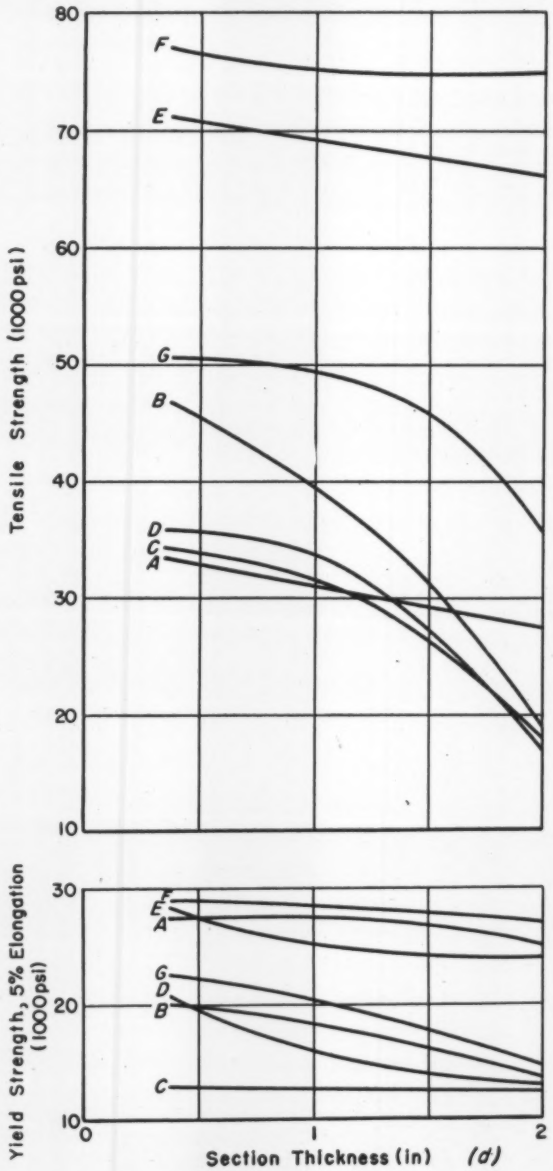


Fig. 4—Section-size effect on strength in tension of cast metals; *a*—gray iron, *b*—cast steel and nodular iron, *c*—Meehanite, d—an aluminum and several copper alloys



A—Aluminum (93.25 Al, 5 Si, 1.25 Cu, 0.5 Mg; solution-treated and aged)
B—Tin bronze (88 Cu, 8 Sn, 4 Zn)
C—Red brass (87 Cu, 3 Sn, 7 Zn, 2.5 Pb)
D—Tin bronze (85 Cu, 5 Sn, 5 Zn, 5 Pb)
E—Manganese bronze (59 Cu, 0.8 Mn, 1.25 Fe, 0.8 Al, bal Zn)
F—Aluminum bronze (88.5 Cu, 9 Al, 2.5 Fe)
G—Silicon bronze (93.7 Cu, 4.5 Si, 1.8 Fe)

be made in reported values for evaluation purposes.

Form and Size Effects: Section size has a definite effect on strength values in tension of most engineering materials. The effect can be noted by comparing figures for sheet and rod tensile strengths for the same metal in equivalent hardnesses. In most cases, smaller section thicknesses show appreciable higher tensile strength values. These differences show clearly in *Fig.* 3 in which fracture-stress curves for specimens of silicon-killed SAE 1025 steel of three different radii are compared.[1]

Results of changes in form or contour on strength in tension have primarily been investigated as notch effects. Sharpness of notch has a definite effect on tensile strength, as shown in *Fig.* 3, which shows the effect of circumferential, circular-contour notches of varying degrees of sharpness on fracture stress. The effect is caused by stress concentration and can be considered mostly as an effect of the geometry of the part; general corrections can be made in design to compensate for notch effect. Sensitivity to notch effects varies, however, from one metal to another. Although notch sensitivity has a definite effect in static tests, the effects are more profound under impact or fatique conditions. Notch effects are therefore usually determined by endurance or notched-bar impact tests.

Section size has a strong influence on the tensile strength of cast metals, but here the effect is largely due to differences in cooling rate (mass effect) and resultant differences in structure. Chill casting in the smaller sizes thus accounts for the higher tensile strength of these sizes. A similar effect can be noted in die castings, in which tensile strength of test bars is likely to be much higher than tensile strength of actual pieces. As section size is increased, tensile strength goes down, but at a slower rate with increased section size.

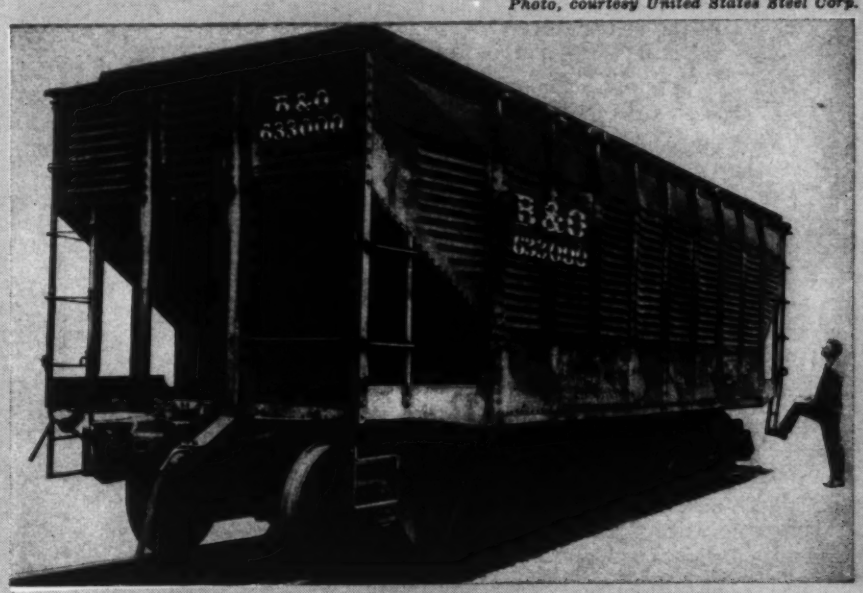
Decrease in tensile strength with increasing section thickness is shown in *Fig.* 4*a* for gray iron (core properties)[2]; for a typical cast steel and two types of nodular iron in *Fig.* 4*b* (core properties)[2]; for Meehanite in *Fig.* 4*d* (average properties)[3]; and for an aluminum and several copper alloys in *Fig.* 4*d* (average properties).[4]

Curves such as these should not, however be accepted without some investigation. Reductions shown in tensile strength may be the results of testing specimens machined from the core of the test block—the weakest part of the casting—or they may be average figures obtained by testing several specimens from the casting or one specimen

1. References are tabulated at end of article.

Nineteen years of use have proved the capabilities of the high-strength, low-alloy steel used in this freight car. The experimental hopper car was built in 1934 from high-strength, low alloy sheets of one-half the section thickness recommended for carbon steel. Through utilization of the higher design strength range of this steel, the car has an empty weight of only 31,200 pounds, a pay load capacity increase of more than 6 tons over standard hopper cars. One of the other advantages of the Cor-Ten steel was an increase in corrosion resistance over carbon and copper steels. Slope and cross-ridge sheets and longitudinal hoods required some repair and replacement once during the period, but side and end sheets are still in good shape.

Photo, courtesy United States Steel Corp.



from midway between the center and the ouside edge of the casting. Actual tensile figures for any section lie between the figures for core properties and the harder and stronger exterior of the casting. In testing wrought steel bars over 1½ inches in diameter, for example, recommended ASTM procedure is to machine the specimen from midway between the surface and center of the bar.

Directional Strength: Cast metals have uniform and very similar properties in different directions. Wrought metals do not. Yield and tensile strengths for most metals are frequently different in one direction than another; the differences, except for zinc and alloys, are usually not great. But ductility may be much lower in the transverse direction (right angles to rolling). Consequently, the standard longitudinal tensile test may not show true ability to withstand combined stresses; however the difference in ductility may not make any practical difference, so each case must be evaluated.

Differences in directional strength for zinc and alloys are quite marked, and also vary with speed of pulling, cold drawing, or extrusion. Similar directional tendencies can be noted in copper alloys which have been severely worked between anneals. A "preferred orientation" crystal structure is formed, with the crystals elongated, and is not removed by the anneal. Ductility becomes markedly different in the two directions, and tensile strength is also affected.

Most plastics, and particularly filled and laminated plastics, are anisotropic. The extreme cases are low-pressure laminates with unidirectional cloth reinforcement; strength properties of final laminates with the cloth laid in one direction are highly directional, *Fig.* 5.[5]

Molded plastics generally show certain directional properties because of flow in molding, dependent upon mold design and gating. These directional properties may be accented with fiber-filled plastics, since fibers tend to orient themselves along flow lines.

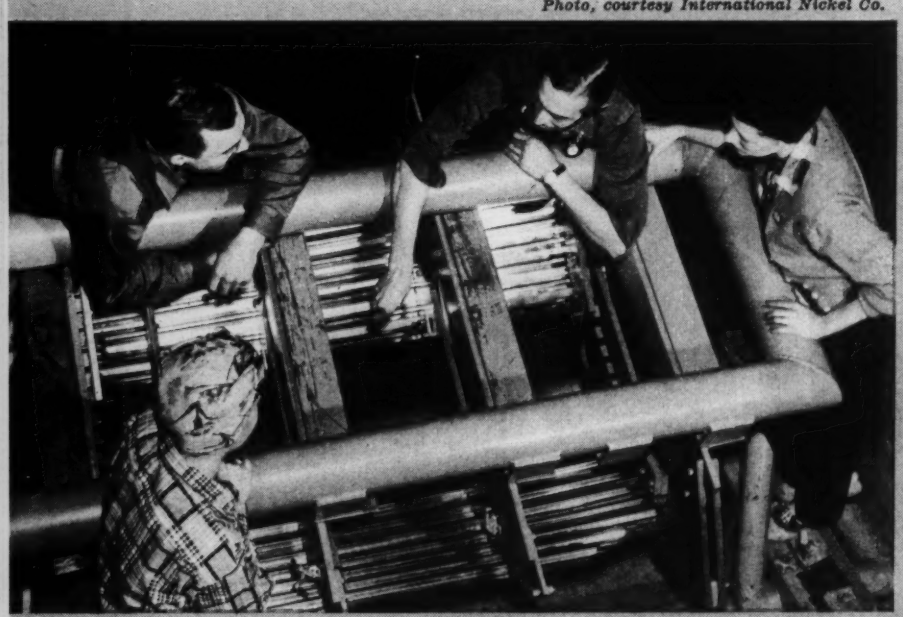
Variations Between Lots: Tensile and yield strength figures are always given as either "typical" or "minimum" values, since variations between different lots of the same material can be quite great, and variations can even be expected in bars from a single ingot.

Some idea of the distribution and magnitude of variations from heat to heat can be gained from *Fig.* 6, which represents the results of testing 600 commercial lots of medium-carbon steel castings which were specified by minimum tensile figures.[6] Variations in wrought steels are similar, since quite a bit of scatter is encountered in tensile properties from heat to heat of steels falling within a standard AISI or SAE chemical analysis. Magnitude of tensile strength variations can conceivably range up to 15,000 to 20,000 psi from the average; with careful control employed today, it is unlikely that the variation is this great. However, one of the prime reasons for developing the AISI series of H steels was to limit such variations by specification of a hardenability (and consequent tensile strength) band within which the steel falls, rather than specifying the steel by chemical composition only.

Variations within single heats sometimes show comparable spreads of tensile properties. Typical values for rimmed (A) and killed (B) carbon- steel plate are:

	Steel A	Steel B
Tensile strength (1000 psi)	55.7-62.2	58.1-63.8
Yield point (1000 psi)	26 -28	28 -31.2

Photo, courtesy International Nickel Co.



Carrying a 3500-pound engine, this stainless-steel nacelle barrel weighs only 175 pounds, an example of the high stress level possible through efficient materials utilization and design. Quarter to full-hard type 301 stainless is used with minimum tensile strength ranging from 125,000 to 185,000 psi, allowing thicknesses of only 0.012 to 0.050-inch to be used. The nacelle barrels are built by Solar Aircraft Co. for the Lockheed P2V-5 "Neptune" patrol plane.

Variation even occurs with position in the ingot. Hot rolled bars of C1141 steel showed the following scatter in tensile strengths with different ingot positions:

	Tensile Strength (1000 psi)	Yield Point (1000 psi)
Top	108.8	64.8
Middle	102.0	62.5
Bottom	99.4	60.5

Thus, quite a bit of allowance must be made when considering "typical" strength figures for possible differences in the actual material; by the same token, minimum specifications must also permit some leeway from typical values.

Conditioning: The effect of heat treatment on hardness of steels, tensile strengths and relation between the two will be detailed later in the series. Summing up the subject briefly at this point, for one specimen size, annealing reduces tensile strength from the as-rolled condition; normalizing produces strength ranging from slightly below to considerably above as-rolled strength depending upon carbon and alloy content of the steel; quenching and drawing produces strengths up to four times the as-rolled strength, with the lower tempering temperatures resulting in higher strength.

Without extensive metallurgical description, it should be noted that relations between tensile strength, yield point hardness, reduction of area and tempering temperature are closely similar for all steels in the SAE 1000, 1300, 3100, 4100, 2300, 4600, 5100 and 6100 series containing between 0.30 and 0.50 per cent carbon *if hardened throughout.*

All steels, however, do not have the same ability to be through-hardened; a 1-inch diameter specimen of one steel may be through-hardened after quenching and tempering, whereas a second steel may be hardened for only part of its diameter. The method of determining which steels will have the necessary hardenability and consequent tensile strength involves making an end-quench (Jominy) test for the particular steel at the particular heat-treatment temperature. From the hardenability curve resulting, the hardness pattern can be determined for any section size.[7]

In considering strength figures for steel, due consideration must be given to specimen size and condition. Values, as often reported, for quenched and tempered rounds from approximately ½ to 1 inch in diameter are not representative of larger heat-treated sections. Even variations within this range can be very considerable. Tensile strength figures for 1½-inch diameter and larger rounds are usually for specimens machined from the mid-radius, rather than the center, of the round. These figures, presumably representative of average tensile strength of the section, are usually higher than for specimens machined from the center of the bar.

Pure or unalloyed metals—copper, aluminum, and even iron—cannot be heat-treated to obtain higher hardness and strength. To be heat-treated, all metals must have certain amounts of impurities or alloying ingredients. Thus, copper, alpha brass or the pure forms of aluminum do not respond to heat treatment. These metals can be hardened and strengthened by cold work only.

Although most copper alloys and some aluminum alloys are designed for strength improvement primarily by cold working, many can be strength-

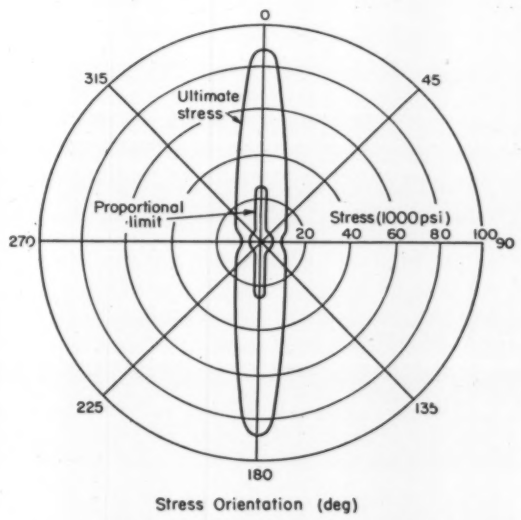


Fig. 5—Above—Variation of tensile strength properties with direction of stress for a polyester plastic, glass-cloth laminate, made with unidirectional 143-114 glass cloth, parallel-laminated

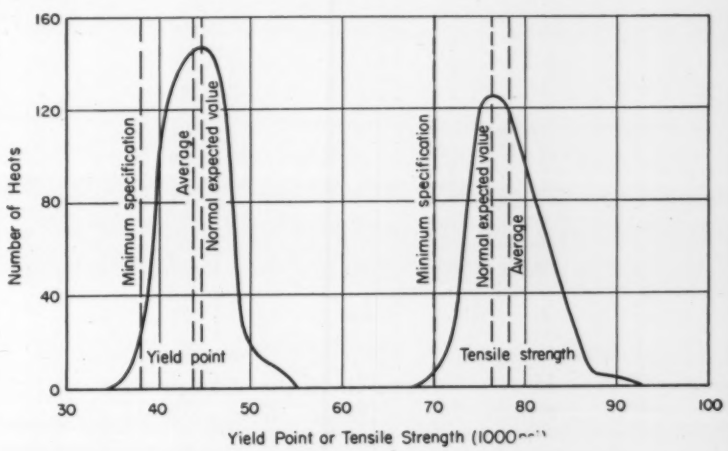


Fig. 6—Right—Distribution of tensile and yield strength values for 600 commercial heats of medium-carbon steel castings

ened by solution heat-treatment or precipitation hardening procedures. In most cases, stabilizing, aging (artificial or natural), and/or cold working are necessary to stabilize properties. Stabilizing or aging reduce strength a certain extent from the original hardened condition.

In aluminum alloys, the type of heat treatment and/or cold working is specified by a temper designation following the type designation. In general, these are −F, as fabricated; −O, annealed, −H, strain hardened with or without subsequent thermal treatment to produce partial softening; −W, the unstable condition following solution heat-treatment; and −T, thermally treated to produce stable temper with or without aging, stabilizing or cold work.

Plastics are used in the "as fabricated" condition, but several factors affect tensile strength in every use. One is aging, which reduces strength. Others are temperature and humidity, which both have large effects on tensile strength. Temperature and humidity are carefully controlled on tensile tests of plastics according to ASTM specifications. But actual strength may differ because of effects of these factors.

Cold Working: Reduction in metal thickness by cold working increases hardness and tensile strength. Theoretically, if cold working is carried to the point of complete crystal deformation, the material is said to be full hard or completely cold worked. In practice, this is never done, but reductions up to 98 per cent—equivalent to rolling from 0.5-inch thickness to 0.01-inch thickness—are possible.

One method of specifying amount of cold work is by per cent reduction; a second by the designations ⅛, ¼, ½, or full hard. Except for strip, in which these designations (plus "extra hard," "spring hard" and "extra spring hard") mean definite reductions according to Brown & Sharpe gage, the meanings of these terms are not too exact. A third method, of specifying final hardness of the metal according to one of the standard hardness tests or by specifying actual minimum tensile property values, is probably desirable. *Fig.* 7 shows the effect of cold rolling on tensile strength of several copper alloys.[8] Cold drawing, and cold extrusion have similar effects.

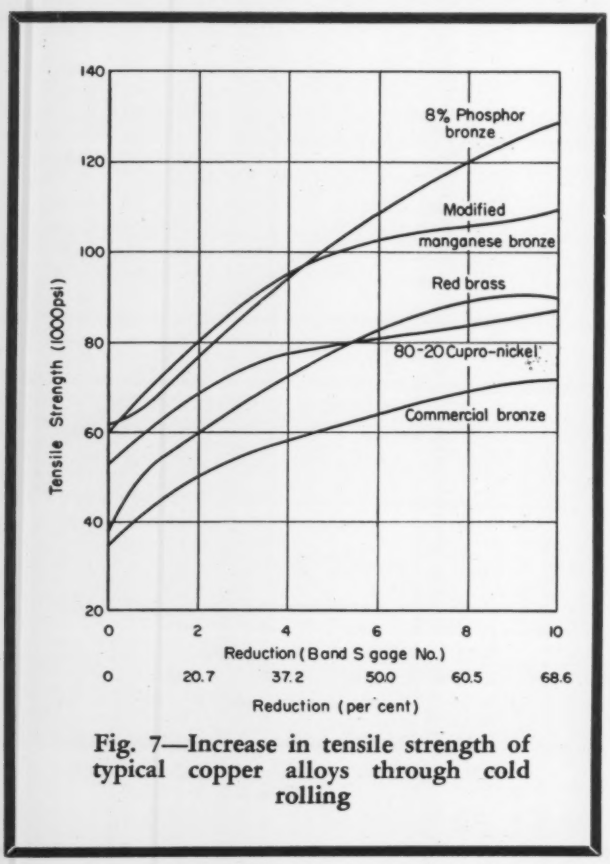


Fig. 7—Increase in tensile strength of typical copper alloys through cold rolling

Other Effects: In comparing actual stresses encountered in service with tensile tests on laboratory specimens, many other factors have an effect. Attempts have been made to determine some of these influences, such as temperature and corrosion. Future articles will consider several of these factors.

Summary: Despite the fact that strength values in tension are widely reported for almost every material, tensile strength properties are almost never used directly in design. Some correction factor, based on experience, fatigue tests, service tests or other modifying influences, is always applied.

Tensile values, however, are widely used for preliminary evaluation of materials and as specification values. For specification purposes, tensile strength serves mainly to insure control of quality and duplication of minimum strength properties between lots. Tensile tests have the advantage of being easily made, are relatively standard, and give reasonably accurate control.

For preliminary evaluation purposes, however, the variations possible make necessary a critical analysis of not only the actual figures, but also the factors affecting these values. Some have been pointed out in this article; the next article in this series will outline more detailed ranges of tensile strength for engineering materials, and will discuss certain other factors for specific types of materials.

REFERENCES

1. M. L. Fried and G. L. Sachs—*Notched Bar Tension Tests on Annealed Carbon Steel Specimens of Various Sizes and Contours*, 51st Annual Meeting, American Society for Testing Materials, June 22, 1948.
2. *Cast Metals Handbook*, American Foundryman's Assn., Chicago, 1944.
3. C. R. Austin—"Section Thickness in Meehanite Castings," MACHINE DESIGN, February, 1951, Page 130.
4. W. J. Reichenecker—"How Section Size Influences Strength Properties of Sand Castings," *Materials and Methods*, July, 1953, Page 80.
5. F. Werren—*Mechanical Properties of Glass-Cloth Plastic Laminates as Related to Direction of Stress and Construction of Laminates*, Paper No. 52-F-36, ASME, 1952.
6. S. L. Hoyt—*Metal Data*, Reinhold Publishing Corp., New York, 1952, Page 242.
7. A. L. Boegehold—"Selection of Automotive Steel on the Basis of Hardenability," *Hardenability of Alloy Steels (Contributions to the Metallurgy of Steel—No.* 11), American Iron and Steel Institute, New York, 1949.
8. R. A. Wilkins and E. S. Bunn—*Copper and Copper Base Alloys*, McGraw-Hill Book Co. Inc., New York, 1943.

Counter-Stacker Combines Electric-Pneumatic Design

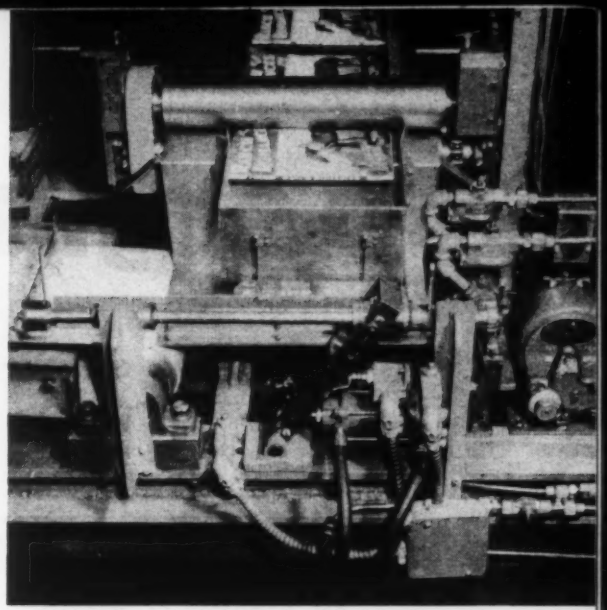


Fig. 1 — Using many standard parts, the counting and stacking machine will stack approximately 12,500 pieces per hour

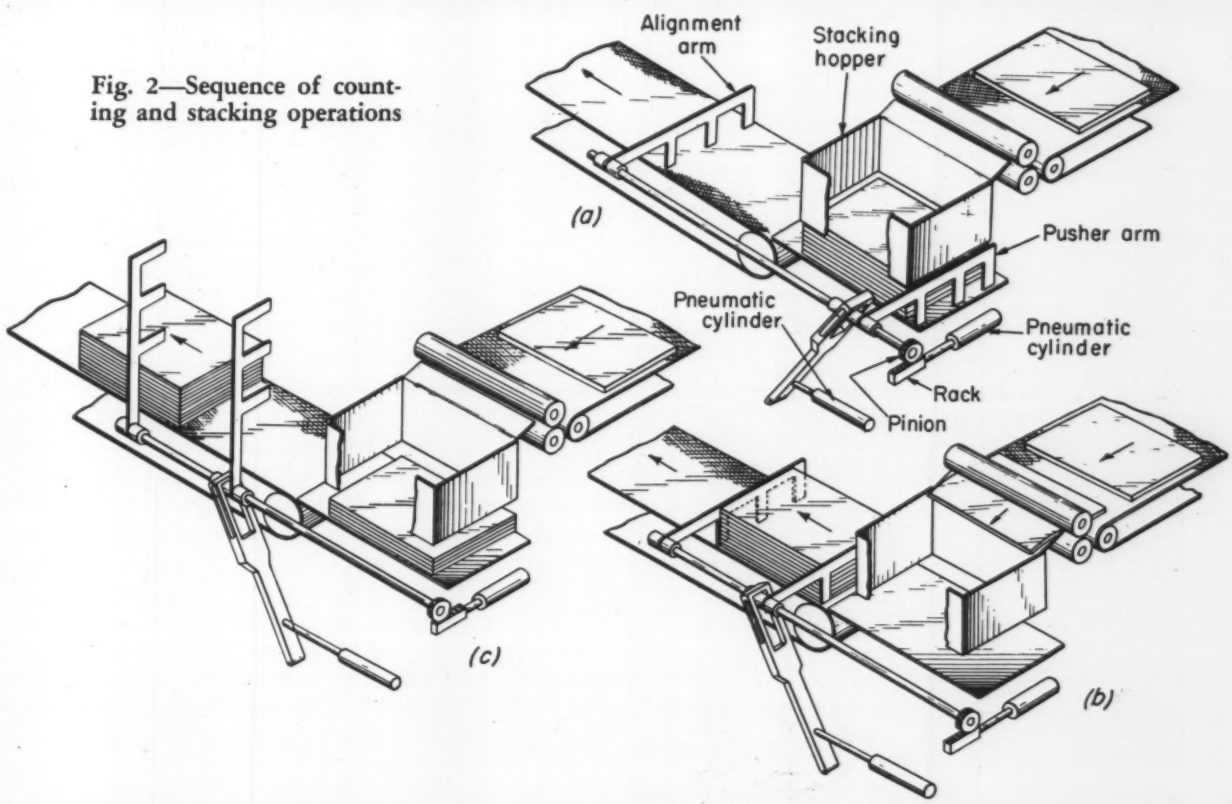
A RECENTLY developed machine, *Fig.* 1, automatically counts and stacks books, magazines or other items of the same general configuration, and then places the counted and stacked articles on a conveyor belt at a maximum rate of approximately 12,500 pieces per hour. The machine is manufactured by Count 'N Stack Mfg. Co.

In operation, items to be counted and stacked trip a counting switch, which actuates an electric counter as they fall from the end of a conveyor into a stacking hopper, *Fig.* 2*a*. When the required number of articles have been stacked, the counter energizes a four-way solenoid valve to actuate a pneumatic cylinder and push the stack onto the outgoing conveyor belt. An alignment arm, *Fig.* 2*b*, keeps the stack neat, even though the machine is operating at high speed.

Completion of the delivery stroke of the pusher arm actuates a limit switch, solenoid valve and pneumatic cylinder, causing the rack and pinion to rotate both pusher and alignment arms to a vertical position, *Fig.* 2*c*, permitting the conveyor belt to carry the stack away. Another limit switch, actuated as the arms reach a vertical position, initiates the return of the pusher arm to its original location at the right end of the machine while still vertical. Return of the pusher arm then causes the rack and pinion to rotate the arm to the horizontal position, where it is ready for the next cycle.

The counter is easily set to stack almost any desired number of items. Power requirements, of course, vary with the number and weight of the items. A ¼-horsepower motor drives the machine shown, which operates with a minimum air pressure of 15 psi.

Fig. 2—Sequence of counting and stacking operations



Designing Springs

How to achieve simplification and reduce costs

Part 3—Torsion Springs

By Stanley L. Albright

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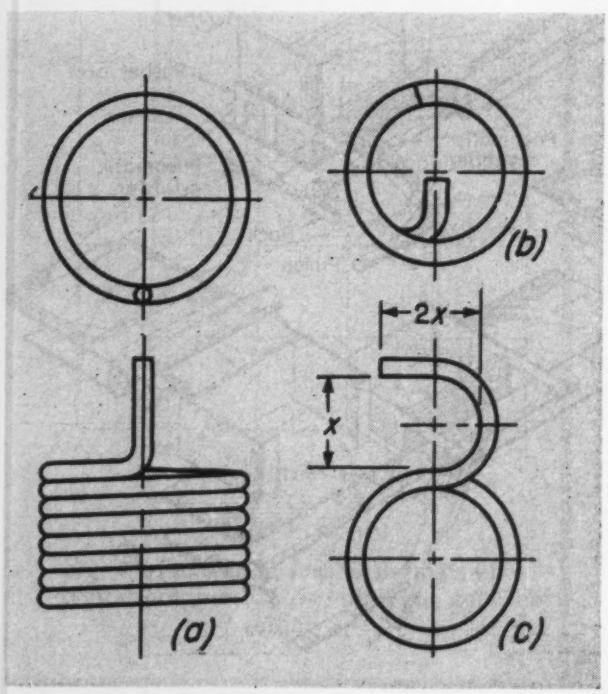
Hunter Spring Co.
Lansdale, Pa.

A PRACTICAL approach to the design of compression and extension springs for lower cost has been demonstrated in two previous articles. In this, the concluding article of the series, torsion springs will be treated.

Although similar in many respects, each of the three spring types involves fundamental differences which must be considered separately in design. In each case, of course, design must begin with a careful evaluation of load magnitude, permissible deflection and space requirements. In the final analysis, however, the successful completion of any design to meet the particular application requirements and provide the best performance at lowest cost will usually depend on the designer's ingenuity and ability to utilize to the fullest the multitude of spring forms made possible by modern spring production methods. The specific designs presented in this series of articles illustrate a number of the troublesome problems commonly encountered and their solution. These, of course, are only representative—the full value of designing for lower cost can be achieved only through an alertness to the many possibilities evident.

METHODS OF ATTACHMENT

A common method of attachment for torsion springs, the design at *a* employes a straight end parallel to the spring axis for insertion in a hole or simply to rest against an external support. However, there are very few torsion-spring applications in which the radial end at *b* will not be equally satisfactory in operation. In both cases the methods of external attachment are similar. The important difference, however, is that the end at *a* requires an additional bending operation in which a tangential end is bent parallel to the spring axis; the end at *b* is automatically produced.



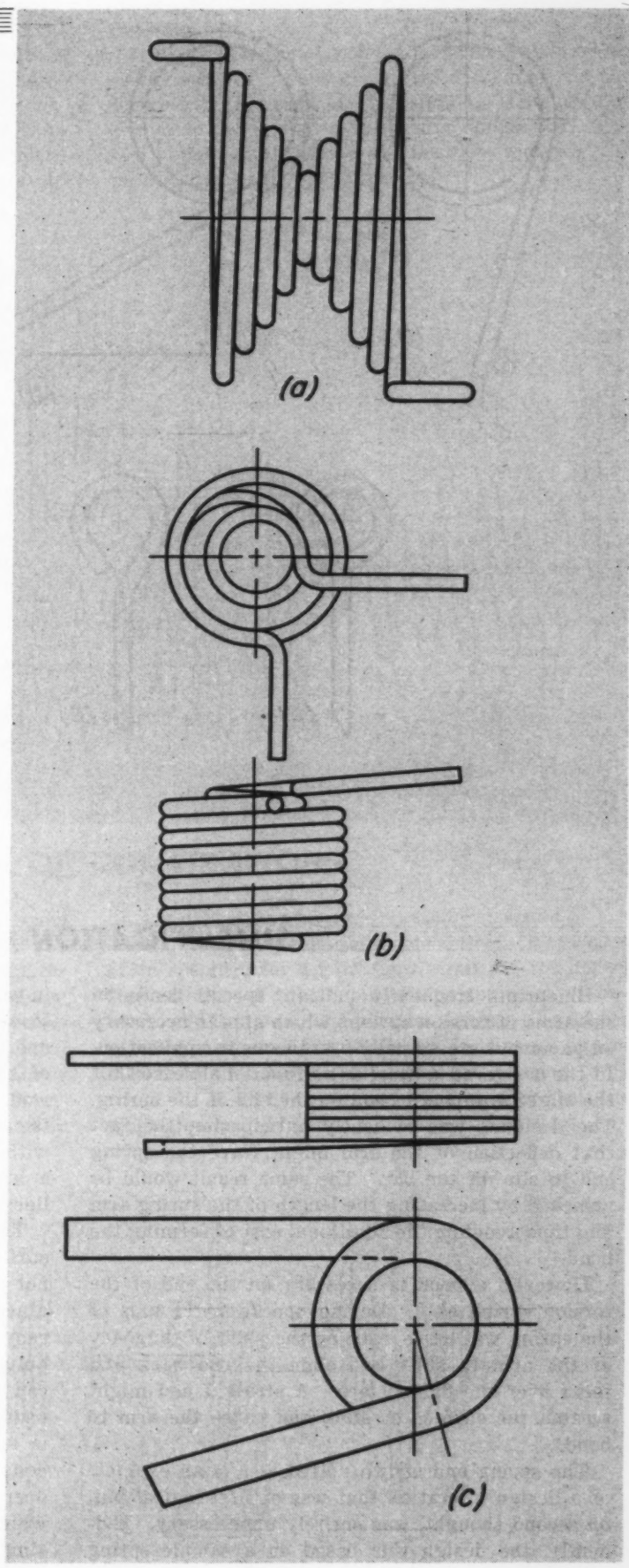
Although the torsion-spring end at *c* appears more difficult to form than that at *b*, it may also be automatically produced on the coiling machine since the end itself is perpendicular to the spring axis. For any of the three designs shown an additional cutting operation may be necessary if the straight wire above any bend is too short. A bend cannot be formed properly in spring wire unless there is a sufficient straight length. If short ends are necessary, the bend is formed with a long end which is cut to the specified length in an additional cutting operation. In the designs at *a* and *b*, the straight end must be at least twice the wire diameter. For the design at *c*, length of the return end must be at least twice the opening to permit 180 degree forming without recutting.

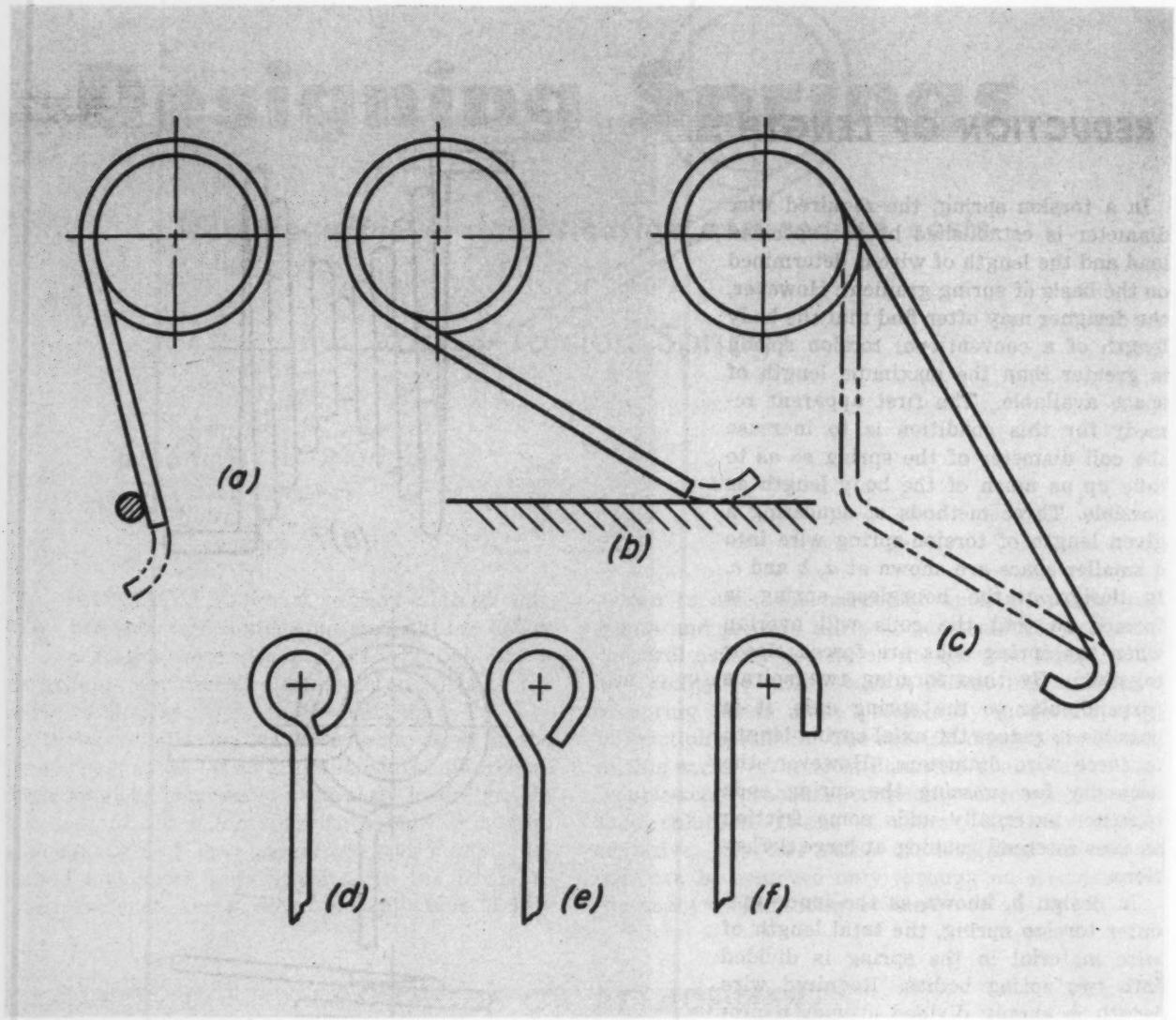
REDUCTION OF LENGTH

In a torsion spring, the required wire diameter is established by the specified load and the length of wire is determined on the basis of spring gradient. However, the designer may often find that the body length of a conventional torsion spring is greater than the maximum length of space available. The first apparent remedy for this condition is to increase the coil diameter of the spring so as to take up as much of the body length as possible. Three methods of squeezing a given length of torsion-spring wire into a smaller space are shown at *a*, *b* and *c*. In design *a*, the hourglass spring is formed so that the coils will overlap when the spring ends are forced closer together. By thus forming two spirals perpendicular to the spring axis, it is possible to reduce the axial spring length to three wire diameters. However, the necessity for pressing the spring ends together externally adds some friction as does intercoil rubbing at large deflections.

In design *b*, known as the inner-and-outer torsion spring, the total length of wire material in the spring is divided into two spring bodies. Required wire length is simply divided in such a proportion that there is no rubbing between the inner and outer coils at the largest deflection. The inner-and-outer torsion spring is also used when it is advantageous to have both spring ends in the same plane, where deflection of the spring body due to transverse moment between the arms cannot be tolerated. It is common practice, for example, to specify both torsion spring arms on the same end for double-throw operation in which one end first deflects clockwise and then the other end deflects counterclockwise.

The last method for reducing the axial length of torsion springs, design *c*, is to use flat wire with the short dimension parallel to the spring axis. This method is not always practical or possible since rectangular wire materials are more expensive and the sizes required are not always available. In addition, there may be some difficulty in forming the spring.





SIMPLIFICATION OF BENDS

Blueprints frequently indicate special bends on the arms of torsion springs which appear necessary on paper but are actually extraneous in application. In the design at *a*, there is no functional reason for the slight downward bend on the end of the spring. The designer was evidently anticipating the fact that deflection of the arm might force the spring end to slip off the bar. The same result would be achieved by increasing the length of the spring arm and thus avoiding the additional cost of forming the bend.

However, a bend is necessary on the end of the torsion spring at *b*. During operation the axis of the spring will move, causing the point of tangency of the arm to shift and slide the end back and forth over the flat surface. A straight end might scratch the surface or stick and cause the arm to bend.

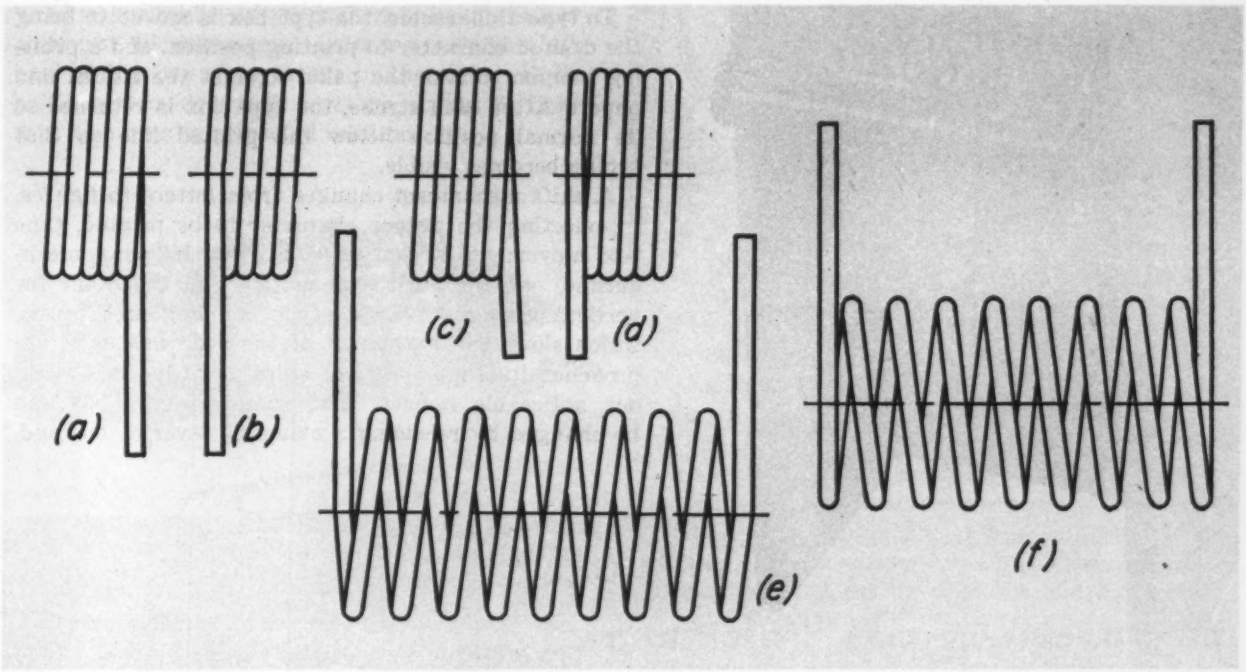
The spring end shown dotted at *c* is an example of a design alteration that was at first logical but, on second thought, was entirely unnecessary. Evidently, the design was based on a sample spring in which the dotted end was straight and horizontal. However, a greater clockwise deflection was needed and the obvious solution was to bend the outer half of the arm upward so that the hook on the end would move through a greater angle before hitting the stop. The same result was finally achieved without an additional bending operation by forming a straight spring arm as indicated by the solid lines.

The spring end at *d*, such as specified for thumb surfaces on the ends of torsion brush springs, cannot be formed in spring wire without special manufacturing methods, even though such shapes are easy to form with softer wire materials. Differing only in that the hook end is straight, the hook at *e* can be formed in standard bending operations and usually does the same job. The straight hook *f*, is less expensive than the hook at *e* and may be equally satisfactory. Although secondary bending operations are necessary in either case, the design which is shown at *f* can be formed faster and with a simpler tool.

SPECIFICATION OF FORM

The two tangential torsion spring arms shown at *a* and *b* often appear on blueprints but cannot be formed. While both of these arms are perpendicular to the spring axis, either straight, *a*, or with a slight bend, *b*, neither type is feasible on close-wound torsion springs because of interference between coils at the ends of the spring. Actually, the spring arms will be parallel to the helix angle as shown at *c*. If the arms must be perpendicular to the spring axis, the end coils can be leveled as at *d*, necessarily leaving a slight gap between the last two coils.

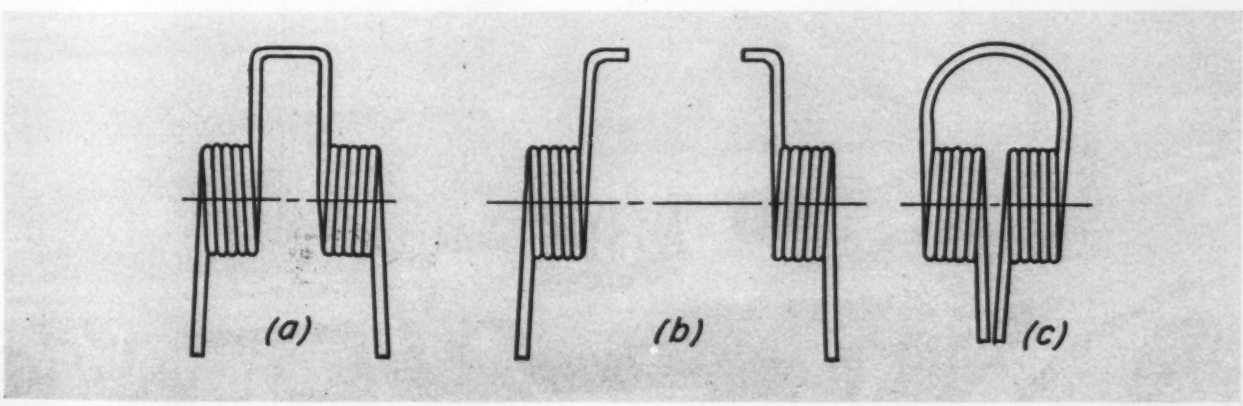
It is possible for perpendicular arms to be formed on the ends of open-wound torsion springs. In the design at *e*, for example, the ends are bent perpendicular to the spring in a secondary operation. The same effect can also be obtained by squaring the ends automatically as shown at *f*.



SELECTION OF COMBINATIONS

Applications requiring springs with two end arms and a center arm may be served with either the double torsion spring, *a*, or the pair of conventional torsion springs, *b*. The single-body springs are coiled automatically in any size on a torsion machine. The double spring may also be coiled automatically and, therefore, will cost less in smaller sizes and large quantities. The only real advantages for the double spring are greater stability during deflection and possibly faster assembly.

The torsion spring with the outside loop, *c*, is often specified for applications requiring the deflection stability of the double torsion spring, *a*. However, the outside-loop torsion spring should be avoided whenever possible since it is more expensive than the double spring and can be made only when the straight center arms are shorter than the loop opening.

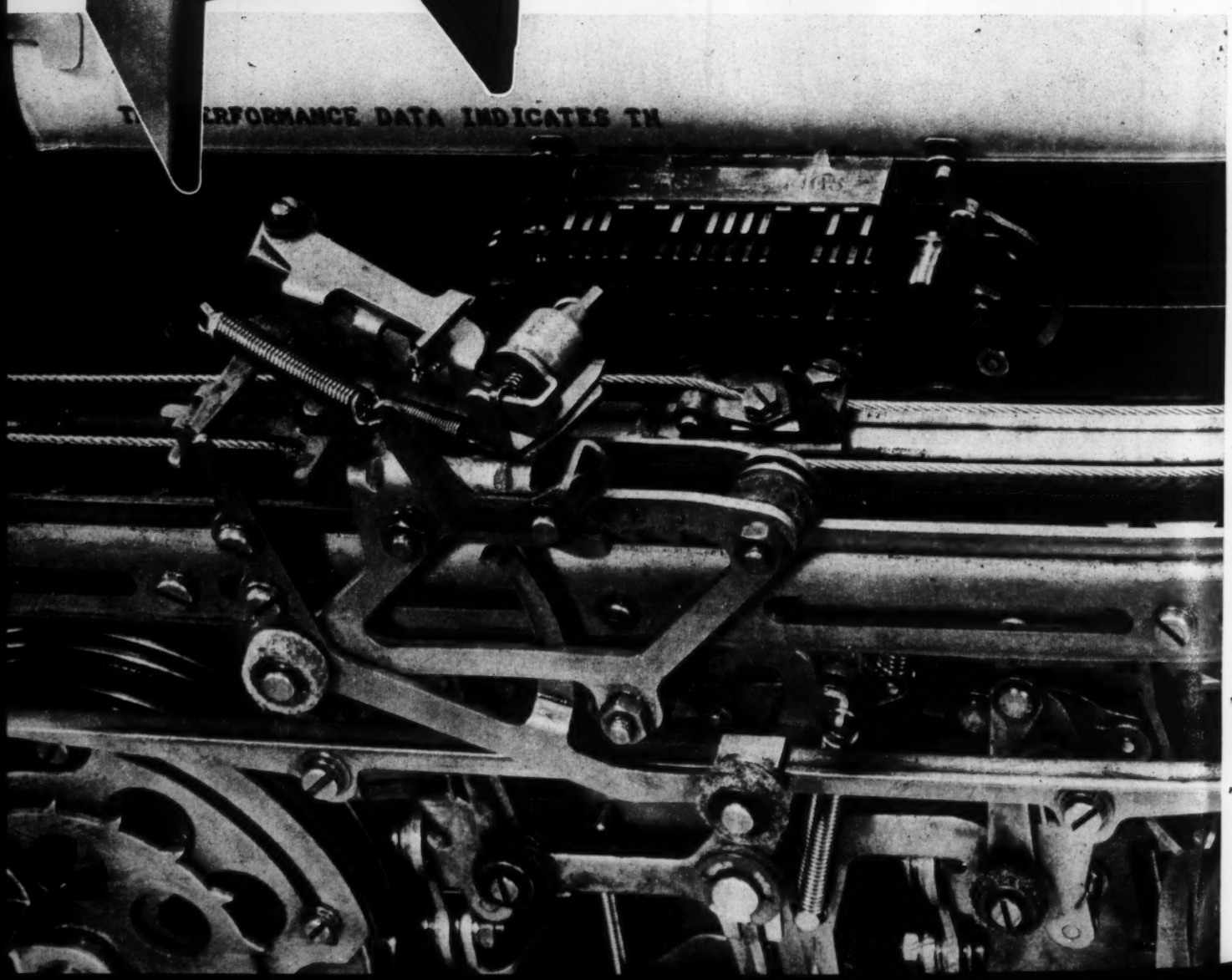


Teletypewriter Redesigned for

SPEED up to 100 words per minute was one of the design objectives in developing the new Model 28 teletypewriter of the Teletype Corp., accompanied by quieter operation and easier maintenance.

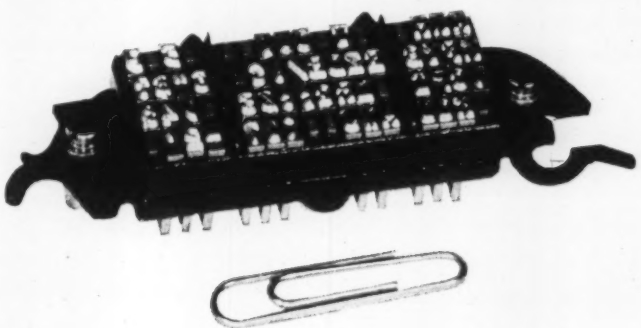
To type a character, the type box is moved to bring the desired character to printing position, and a printing hammer drives the pallet against the ribbon and paper. After each stroke, the type box is returned to its normal position below the printed line so that typing becomes visible.

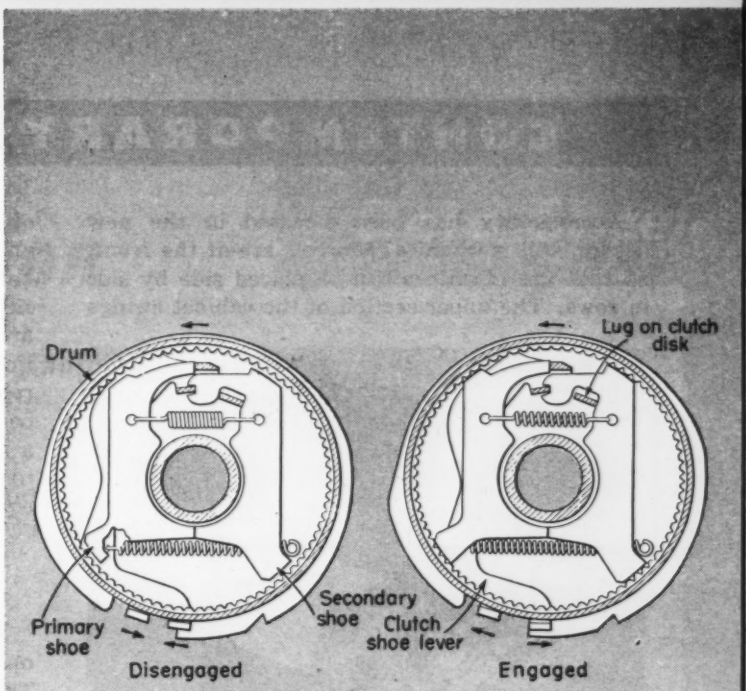
A shift mechanism changes from letters to figures. In selecting the proper character to be printed, type box movement is controlled by two indexing mechanisms, one for horizontal motion and the other for vertical motion. A toggle-type coupling mechanism, which slows the movement of the type box as it approaches its final position, stops the type box without noticeable impact. The complete type box can be changed by releasing a clamping lever at one end.



Speed, Quiet Operation

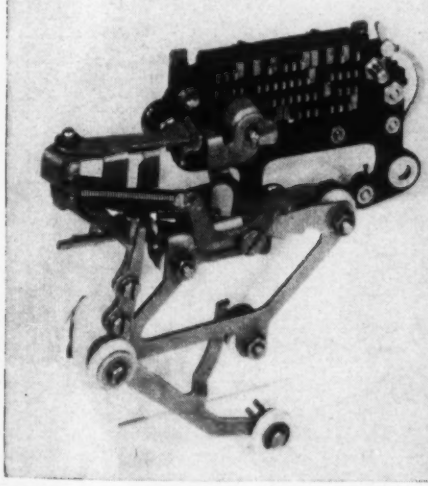
One of the most striking improvement in the new machine is the printing mechanism. Type pallets are carried in a small rectangular box, about 2 by 1 by ½-inch, instead of being mounted on conventional type bars. Pallets are arranged in four horizontal rows, each row having a capacity of 16 characters. Letters are in the left half of the box; figures are in the right. Each pallet is provided with a return spring to hold it in its normally retracted position.

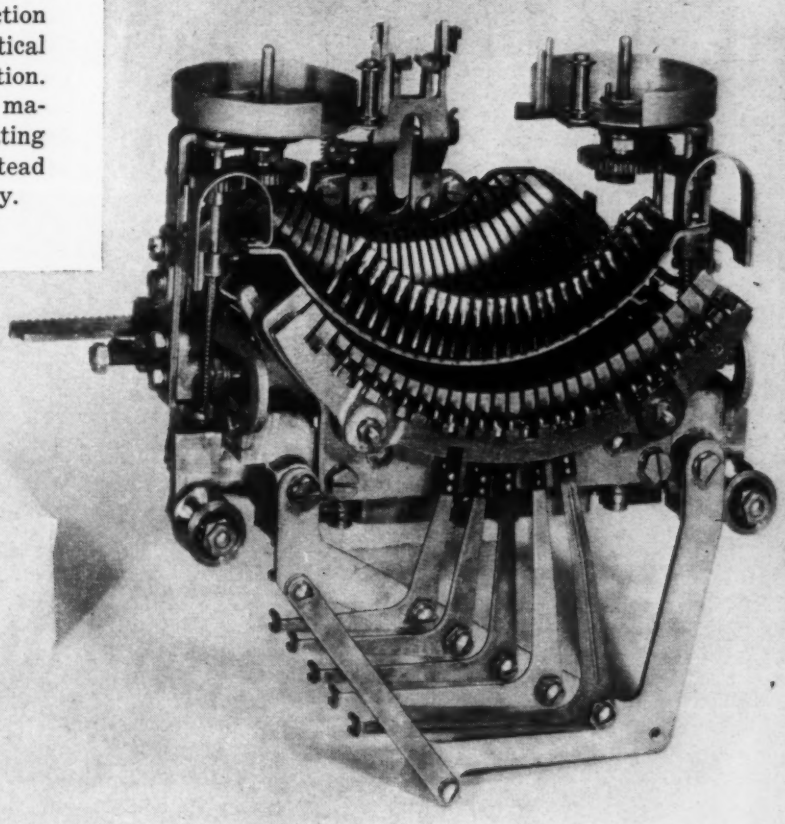




New-design clutch drives the selector cams and various other power actions. The clutch is an all-steel internal-expansion friction type that disengages in the stopped position. The continuously rotating driving member is a steel drum with its inner surface grooved, hardened and ground to give a flat surface, the grooves permitting wear products to fall away. Two hardened-steel members within the drum act as drive shoes and are pressed into contact with the rotating drum by a spring-operated pry-bar. A small spring produces high normal pressure through rigid force-multiplying levers.

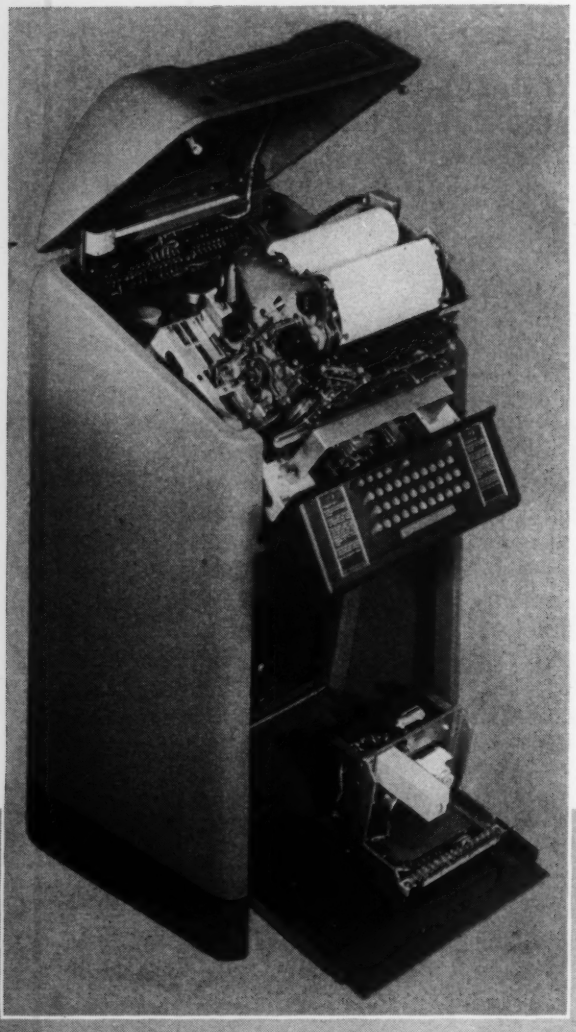
Replacement of the conventional type "basket," right, by the small-size traveling carriage, left, has reduced moving weight from 5 pounds to only 5 ounces. The 10 to 1 weight reduction results in very fast carriage return and practical elimination of gravity effects on carriage motion. Overall reduction in size and weight of the machine has also been made possible, permitting the use of a stamped sheet-metal frame instead of the heavier cast frame formerly necessary.



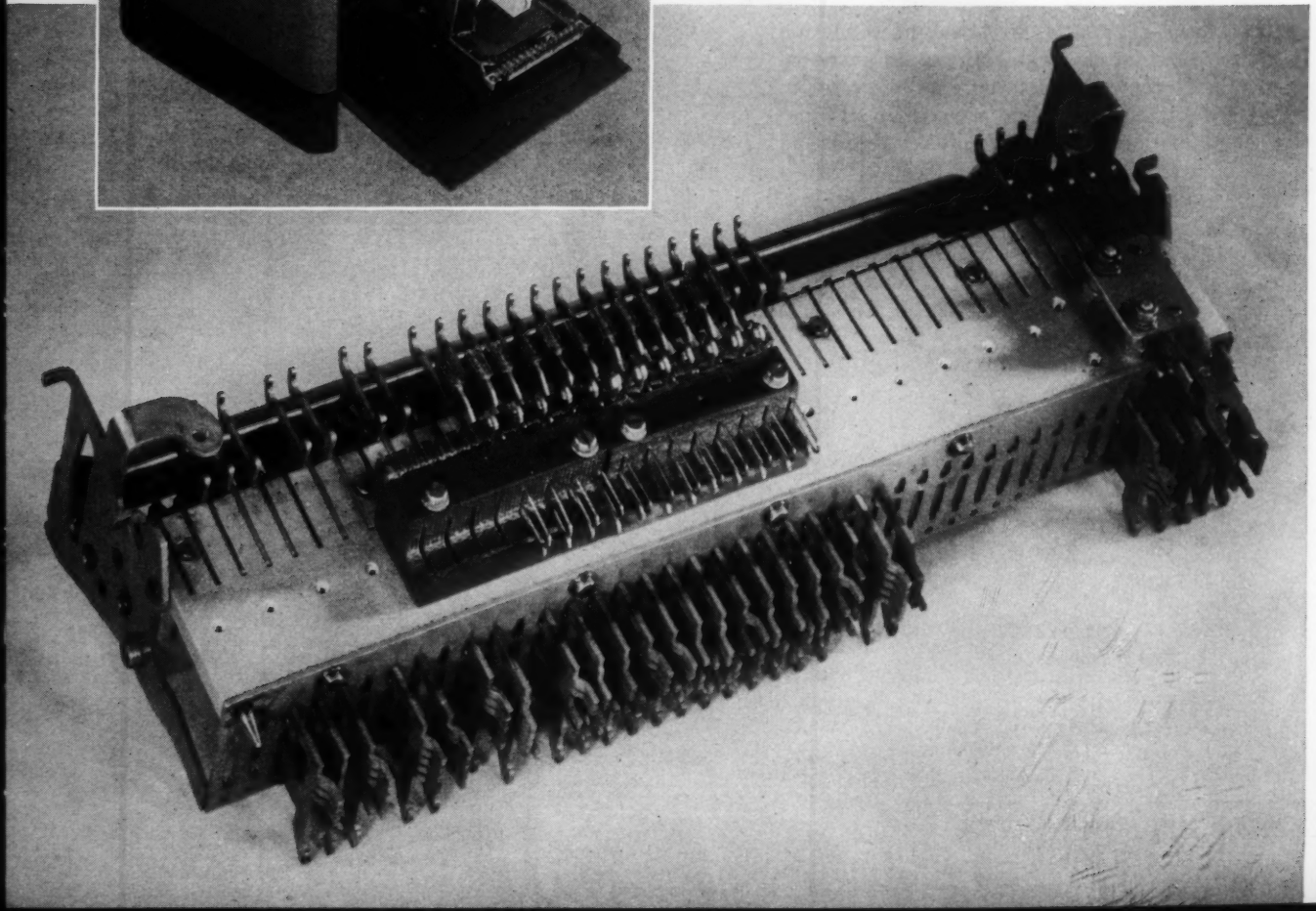


CONTEMPORARY DESIGN

Accessibility has been stressed in the new design. All mechanical controls are at the front, so that the machines can be placed side by side in rows. The upper section of the cabinet swings open to provide access for paper and ribbon insertion and for maintenance. The teletypewriter itself may be swung upward and forward to give access to both sides and rear of the machine. Electrical accessories are in a box behind the machine, permitting installation of a standard machine where circuit termination requirements vary. A rectifier or other apparatus can be mounted on a shelf below the teletypewriter, and a front panel pivoted on this shelf swings downward to provide a mounting surface for other auxiliary equipment if needed.



A "stunt box" controls performance of nonprinting operations, such as carriage return, line feed and shift. The unit, which extends across the full width of the typing unit, engages code bars that also extend across the machine. Notches in the code bars engage the function bars of the stunt box. The stunt box has 42 slots, each of which may hold a function bar capable of responding to an assigned code, so that 42 functions can be controlled. Of these, about ten are reserved for common functions, with 32 available for special purposes. When a key is depressed, a latch is tripped to permit the code bars to move endwise by spring action. In older machines, depressing the key moved the code bars directly, so the new action results in lighter, shallower, more even key touch.



Torsional Deflection

. . . a graphical method for finding angle of twist of shafts having variable cross-sections

By W. H. Mann
Mechanical Development Engineer
London, England

ANGLE of twist for a uniform circular shaft can be determined with comparative ease. In most situations a simple expression which relates unit angle of twist in terms of torque, polar moment of inertia, and modulus of rigidity will suffice. For tapered, stepped and other variable cross-section shafts, angle of twist cannot be as readily determined and calculus is required for an exact solution.

To avoid mathematical complexity, this data sheet describes a reasonably accurate, graphical method for evaluating angle of twist for a shaft with any type of cross-section. Additionally, torsional deflection or angle of twist for the entire shaft is depicted graphically; thus, for any type of loading, position and magnitude of the maximum angle of twist can be easily located.

Uniform Cross-Section Shafts: In *Fig.* 1 a shaft with a uniform cross-section is shown. It is known that (see Nomenclature)

$$BB_1 = Q_u L = R\theta \quad \ldots\ldots (1)$$

where

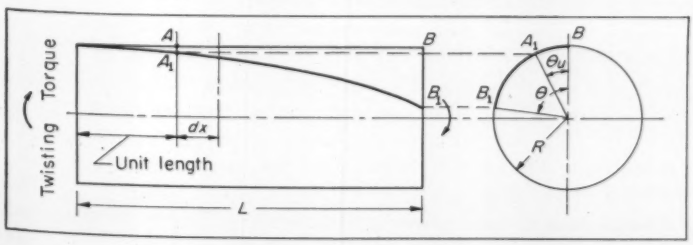
$$\theta = \frac{\theta_u L}{R} \quad \ldots\ldots (2)$$

By definition modulus of rigidity or shear modulus is

$$G = \frac{q}{\theta_u} \quad \ldots\ldots (3)$$

where

Fig. 1—Uniform cross-section shaft



$$q = \frac{TR}{J} \quad \ldots\ldots (4)$$

It follows that

$$\theta_u = \frac{TR}{GJ} \quad \ldots\ldots (5)$$

and

$$\theta = \frac{TL}{GJ} \quad \ldots\ldots (6)$$

Between two cross-sections of the shaft, which are a distance dx apart, angle of twist is

$$d\theta = \frac{T\,dx}{GJ} \quad \ldots\ldots (7)$$

or the total angle of twist between any two sections such as A and B is

$$\theta_{AB} = \int_A^B \frac{T}{GJ}\,dx \quad \ldots\ldots (8)$$

Tapered Shafts: While T and J may change along a tapered, stepped, and other variable cross-section shafts, modulus of rigidity or shear modulus G is usually constant. Therefore

$$\theta = \frac{1}{G}\int \frac{T}{J}\,dx \quad \ldots\ldots (9)$$

Thus, angle of twist is proportional to the T/J area which can be plotted and integrated graphically.

In *Fig.* 2*a* a T/J diagram is plotted for a tapered shaft. Intergration of this curve will give a value proportional to θ. To make this summation, divide the T/J curve into convenient intervals but not necessarily equal ones by means of points P_0, P_1, P_2, etc. It is usually advantageous to select points that coincide with maximum and minimum ordinates and points where the curve crosses the horizontal axis. Step the curve in such a way that each horizontal line segment between the ordinates to P_0 *and* P_1, P_1 and P_2, etc., provides an area below the curve that balances an area above the curve as shown in the shaded parts of *Fig.* 2*a*. Project the horizontal steps to the vertical axis at points

DATA SHEET

1, 2, 3, etc. Connect those points to pole O located at a convenient distance left of the origin. From Q_0, *Fig. 2b*, draw a line parallel to O-1 until it intersects the P_1 ordinate line at Q_1. From Q_1 draw line Q_1Q_2 parallel to O-2, Q_2Q_3 parallel to O-3, etc. This procedure is continued until the entire diagram is completed. For a tapered shaft, connect the Q points with a smooth curve.

Difference in ordinate height for any two sections determines angle of twist between those sections if the ordinates are drawn to a certain scale.

Angle of twist is

$$\theta = \frac{lmpy}{G} \text{ radians}$$

$$= \frac{lmpy}{G} \frac{180}{\pi} \text{ degrees} \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

where the terms are identified in the Nomenclature.

Other Variable Cross-section Shafts: The same torsional deflection solution procedure is employed for other smooth variable-contour shaped shafts as has been described for the tapered shafts. Angle of twist evaluation in stepped shafts involves the same general approach except that the T/J diagram and twist curve are stepped.

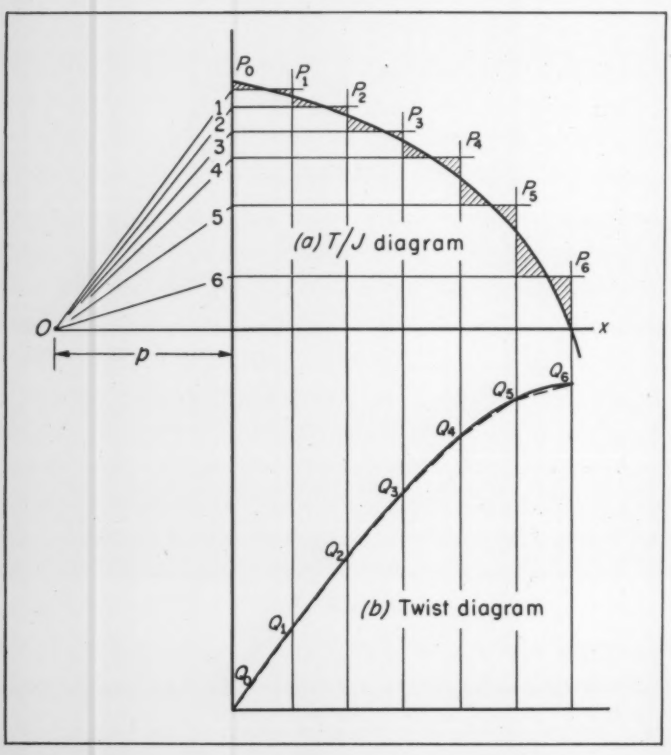
Example: In the stepped shaft shown in *Fig. 3a*, torque is imparted to the shaft through input pulley B, and transmitted by output pulleys A and C which are located at the free ends of the shaft. Assume that power supplied to pulley B which is turning at 200 rpm is 75 hp. Let pulley A transmit 45 hp and pulley C the remaining 30 hp. An expression which connects power, torque, and speed is $P = 2\pi NT/12$ (33,000). It follows that $T = 198{,}000\ P/\pi N$. From this equation the magnitude of torque $T_A = 14{,}200$ lb-in. while torque $T_B = 23{,}700$ lb-in. which is in the opposite direction. Torque for section BC which equals $T_A - T_B = -9500$ lb-in. At the C end of the shaft, an equal and opposite torque must act to balance the system and its magnitude $T_C = 9500$ lb-in. These values are plotted in the torque diagram in *Fig. 3b*.

The T/J diagram in *Fig. 3c* is obtained by dividing the torque by the respective polar moment of inertia for each section of the shaft. For example in section A-1, torque $T = 14{,}200$ lb-in., diameter $D = 4$ inches, polar moment of inertia $J = 25.13$ inches^4, and $T/J = 565$ lb per inch^3. In section 1-2, torque $T = 14{,}200$ lb-in., diameter $D = 4\frac{1}{2}$ inches, polar moment of inertia $J = 40.26$ inches^4, and $T/J = 352$ lb per inch^3. Where there is a step in the shaft, T/J changes abruptly.

To obtain the angle of twist curve, project the horizontal steps of the T/J diagram to the ordinate line through P_0. Treat the curved boundary line in the same manner as described in the section on tapered shafts. Connect the projected points 1, 2, 3, etc., at pole O. Starting at Q_0, which is any arbitrary point on the ordinate line through P_0, draw a line parallel to O-1 until it intersects the ordinate line through P_1 at point Q_1. From Q_1 draw a line parallel to O-2 until it intersects the ordinate line through P_2 at point Q_2. Continue this procedure until the diagram is completed by connecting the Q points with straight lines except for the tapered sections. Difference of ordinate height for any two sections is proportional to angle of twist between those sections.

If $G = 12{,}000{,}000$ psi and the scale factors for this example $l = 10$, $m = 300$, and $p = 1.5$, from Equation 10, $\theta = y/46.5$ degrees. From the scale shown beside *Fig. 3d*, angle of twist can be read directly. The maximum total angle of twist occurs on section AB of the shaft and its magnitude is 0.038-degree. For section BC maximum twist is 0.035-degree.

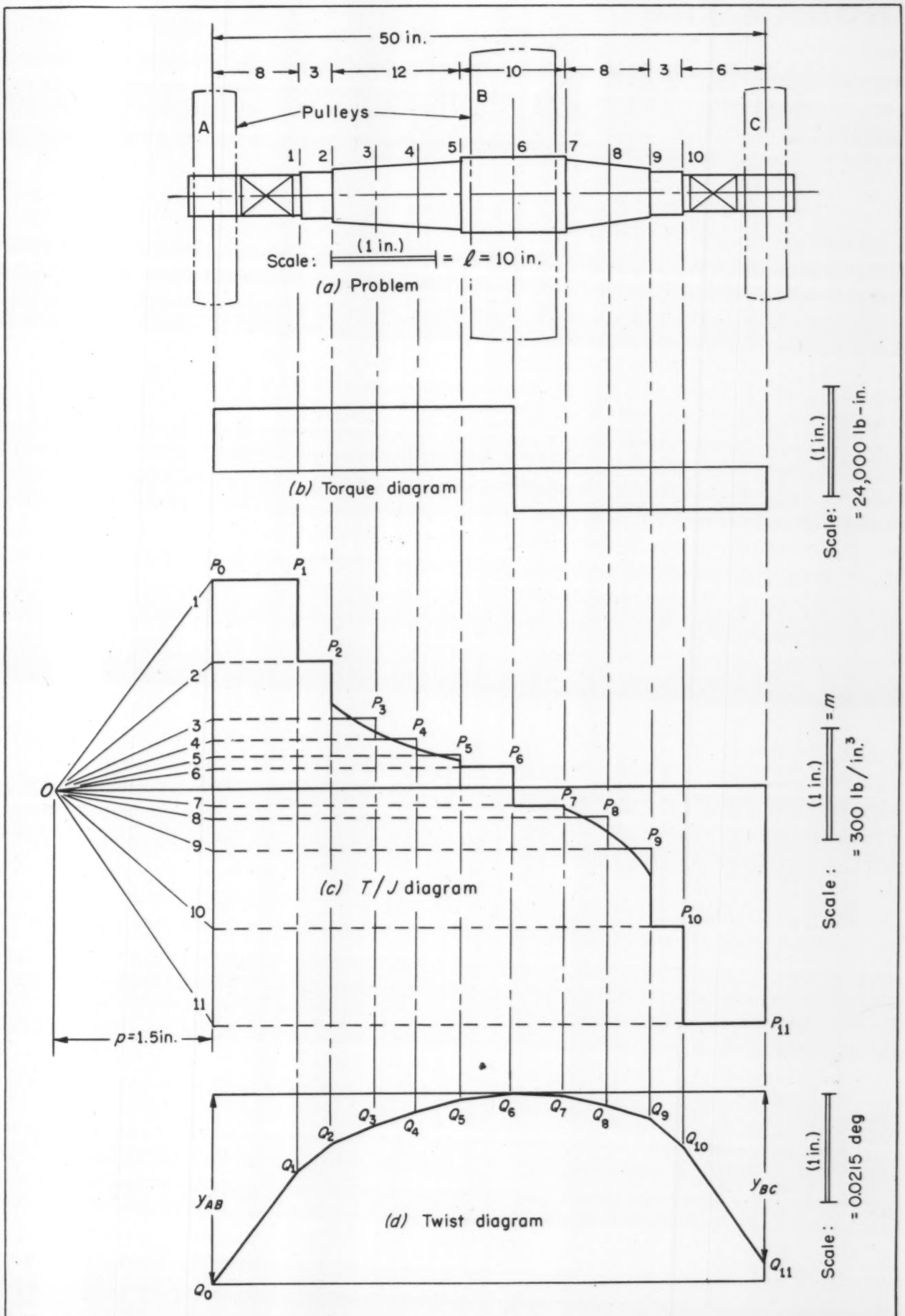
Fig. 2—Diagram sequence for a tapered shaft



Nomenclature

D = Diameter of shaft, in.
G = Modulus of rigidity or shear, psi
J = Polar moment of inertia along shaft, in.^{4}
L = Length of shaft, in.
N = Speed of shaft rotation, rpm
P = Power, hp
R = Radius of shaft, in.
T = Torque on shaft, lb-in.
l = Shaft length scale factor
m = T/J diagram scale factor
p = Distance to pole O, in.
q = TR/J
y = Ordinate of twist curve, in.
θ = Angle of twist per shaft length, radians
θ_u = Angle of twist per unit length of shaft, radians per in.

Fig. 3—Graphical solution of angle of twist along the length of a stepped shaft



Engineering NEWS ROUNDUP

Nickel Controls Lifted

Effective November 1, government controls over the distribution of nickel and its use in nonmilitary products were revoked. The action resulted from a finding by the Secretary of Commerce that the requirements of the national defense for nickel and nickel products can be met without creating a significant dislocation of the normal distribution of these materials in the civilian market, and that no appreciable hardship results from meeting the requirements of nickel and nickel products for national defense.

However, officials of the Business and Defense Services Administration, Department of Commerce, point out that while the decontrol action removes Government restrictions which have handicapped nickel users, the step does not mean there is any increase at this time in the overall supply of nickel for the civilian market. That, they say, can come only from a decrease in military requirements or an increase in the total supply. The action does return to private industry the responsibility for equitable distribution of the available supply after defense needs are met.

Automatic Control Featured At ASME Annual Meeting

Two sessions of the American Society of Mechanical Engineers' Annual Meeting, to be held in New York from November 29 through December 4, will be concerned with automatic control systems for machines. Six papers by experts in the field will be given on Thursday, December 3. The sessions are sponsored by the Machine Design Division of ASME.

Papers scheduled for presentation on the morning of December 3 are: "Automatic Control—Present State of the Art" by F. W. Cunningham, consultant, Arma Corp.; "Automatic Control, Principles of Feedback and Their Application in Machine Control" by Perry L. Nies, application engineer, Ultrasonic Corp., and "Mechanical Analog Computing Elements and Their Application to Machine Control" by Alvin Piatt, Librascope Inc. Thursday afternoon's papers on the subject are: "Proportional Control of Rate-Type Servomotors" and "Dynamic Characteristics of Valve Controlled Hydraulic Servomotors" by J. L. Shearer, assistant professor of mechanical engineering, Massachusetts Institute of Technology, and "Performance Evaluation of Feedback Control Systems" by T. A. Westover, Servo Corp. of America.

Some other papers sponsored by the Machine Design Division are: "A Concept of Fatigue Damage," "Synthesis of the Quadric Chain When the Position of Two Members is Prescribed," "Linkage Design, A Note on One Method," "The Borg-Warner Ford-Mercury Automatic Transmission Control," "Design of Hydraulic Equipment for Heat Dissipation" and "Contributions to Hydraulic Control—6, New Valve Configurations for High Performance Hydraulic and Pneumatic Systems."

SCORPION STINGS: Sting of this Northrop F-89D Scorpion is 104 2.75-inch rockets carried in two permanent wing tip pods. One of the world's most heavily armed all-weather interceptors, it is powered by two Allison J-35 jet engines. The plane arrived at the Air Force Flight Test Center, Edwards, Calif., for the test phase of its development recently

National Manpower Council Discusses Engineer Utilization

Improving utilization of the nation's scientific and professional manpower was the keynote of the October 7-11 Conference called by the National Manpower Council.

Seventy-five leaders in the fields of engineering, medicine, education, industry, science, government and the armed forces met at Arden

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THE TREND in much industrial equipment design is to higher loads at higher speeds. In step with this, Johnson Bronze has developed an entirely new bearing metal, alumium-on-steel, with higher strength, higher load capacity, and resistance to high temperatures. Already these bearings have been hailed by the diesel industry, where these special properties are greatly needed. These roll-bonded Johnson Aluminum-on-Steel Bearings may be used for loads up to 5,000 P.S.I., yet have good conformability, good resistance to shaft wear, good corrosion resistance, adequate seizure resistance and good resistance to fatigue. Tests prove that the bond to the steel back is as strong as the metal itself. You may find it advantageous to incorporate them in your new plans. Write today for complete information.

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House on the Columbia University campus at Harriman, N. Y. to discuss practical methods of implementing the recent recommendations on manpower utilization.

Issues raised by the Council's recent book, "A Policy for Scientific and Professional Manpower," relating in particular to the utilization of engineers, teachers and medical personnel, formed the basis of the conference.

The conference was divided into three working groups — medical, teaching, engineering. Engineering personnel were under the chairmanship of Frank Pierce, Council member and a director of Standard Oil of New Jersey.

Among the papers delivered was "Some Thoughts on the Utilization of Engineers" by George M. Maverick, director of Standard Oil Development Co.'s Employee Relations Department.

Apparatus Industry Leads in Research Expenditures

During 1952 the scientific apparatus and instrument industry's investment in research and development was well over 6 per cent of sales compared to the national expenditure per sales dollar of 2 per cent. By investing three times more per sales dollar than the average of the 2000 manufacturing concerns surveyed, the scientific apparatus and instrument industry continued their pace-setting in research and development programs. (In 1952 an all time high of 3.5 billion was spent by all industry, government, colleges and universities in research and development.)

According to Edward J. Albert, president, Scientific Apparatus Makers Association, one of the most important contributions of the apparatus industry's research and development program centers around working with scientists and engineers on their own highly specialized problems and investigations. Many times a large amount of research dollars is invested in the production of only one piece of intricate equipment for a particular job. Investigative programs of the apparatus industry differ in this way from other industry where research and development dollars are applied to production of thousands or millions of a specific product.

Total number of research employees of the apparatus industry includes over 13,400 technical people or 7 per cent of the total research personnel employed by all reporting companies. In the next seven years statisticians say that American industry will invest 200 billion in research and development—more than has been set aside in the past 30 years.

Industry Urged To Develop Engineers' Qualities

Calling on industry to bring out the best qualities of the engineers it hires, Carlos E. Harrington, chief engineer of Winsmith Inc. asserted that engineering schools in this country are turning out uniformly well-trained graduates who have a keen appreciation of engineering principles.

Speaking at the fall meeting of the ASME at Rochester, N. Y., October 5-7, Mr. Harrington pointed out that the new engineer should not become a cog in the machinery of production. "To realize that he is being treated fairly and that he cannot better his position by changing employers, leaves the engineer free to concentrate on his particular problems. Management should realize that the engineer thoroughly understands the product he is working with and that his knowledge might be valuable to his competition."

Conferences between management and engineers and between engineers themselves are vital in today's progressive organizations. The broadening of the engineer by conferences can be extended by activity in engineering societies, where problems facing fellow engineers are discussed.

GIANT NUTCRACKER will be capable of crushing the bows of a destroyer like a nutshell. Built in Britain for the Royal Navy, the jaws are a gaping 69 feet long, 33 feet wide and 39 feet high when open. Loads as great as 2000 tons can be imposed on the test structure to determine reactions in heavy seas

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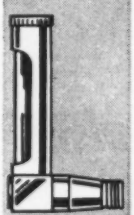

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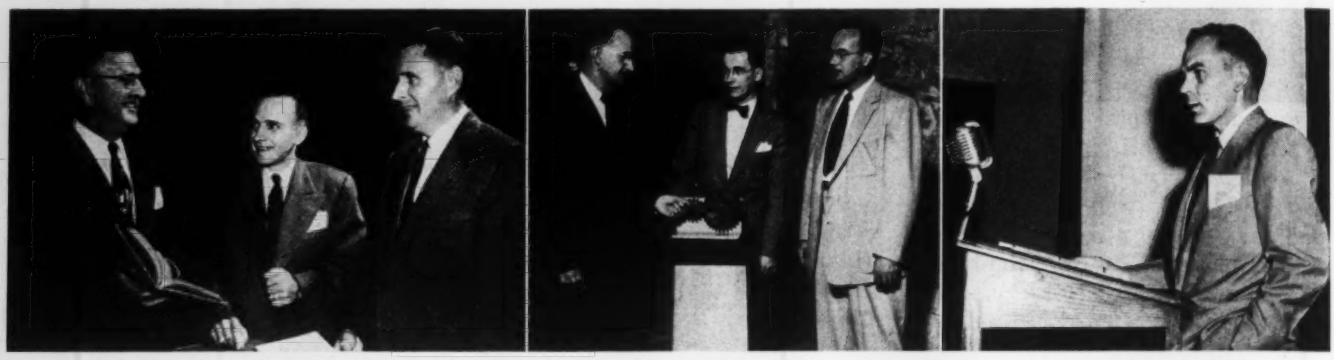


Papers at the First Conference on Mechanisms were delivered by, from left to right; J. Longstreet,, chief textile engineer, Warner & Swasey Co.; R. F. Griffin, research engineer, Warner & Swasey Co.; P. T. Nickson, senior engineer, Raytheon Manufacturing Co.; L. D. Hagenbook, chief engineer, Goodman Manufacturing Co.; A. A. Hess, engineering analyst, Miehle Printing Press and Manufacturing Co.; Professor A. Holowenko and Professor A. S. Hall of Purdue

First Conference on Mechanisms Enthusiastically Received

Engineers from Vermont to California and from Minnesota to Texas as well as 28 engineering educators from 11 engineering schools made up the attendance of approximately 280 at the First Conference on Mechanisms held October 12 and 13 at Purdue University. The Conference was jointly sponsored by the Machine Design Dept., School of Mechanical Engineering, Purdue University and MACHINE DESIGN.

General reaction to the Conference indicates that there is a long standing need for a common meeting ground on mechanism design and application. Preliminary plans are already under way for next year's Conference which will be developed along lines in keeping with the views expressed by those attending. The First Conference served to pinpoint areas of mechanism design and methods or techniques that are of most vital concern today. Future programs will be aimed at correlating available information and filling the gaps in these areas. Advanced concepts will be clarified and direct methods of practical utility in design will be stressed.

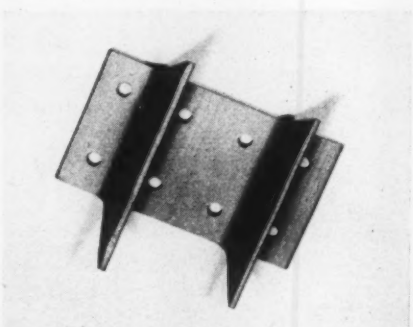
Complete proceedings of the Conference will be published in the December issue. Individual copies of the proceedings will also be available and can be obtained by writing MACHINE DESIGN or using the Readers' Service post cards.

Extruded Steel Used in Aircraft

A recently announced single-step process for extruding steel into complicated shapes is being used to produce a part used in a production-model airplane. The new process was developed by Lockheed Aircraft Corp. and the Harvey Machine Works Co. under a research contract from the Air Materiel Command of the U. S. Air Force.

Complex shapes, previously machined from solid bars can be efficiently produced by the process. Use of the new extrusion method cut 70 per cent from the cost of machine-milling an 8360 Steel radome attachment bracket. Savings as high as 90 per cent are expected in both time and material.

A 1650-ton horizontal press was specially modified to obtain increased ram speed and improve container configuration. Billets of a size suitable for extrusion are heated to approximately 2200 F in a salt bath furnace and then inserted in the press container. Extrusion times are from 2 to 15 seconds.



Radome attachment bracket produced from SAE 8630 steel by extrusion

Metals used in the development program, in addition to SAE 4340 and 8630 steels, are 410 and 431 stainless steels, and Ti 50, L 2748 and RC 130B titanium alloys.

Flight simulators for the USAF F-86 Sabrejet are now in production at Union Switch & Signal Div. of Westinghouse Air Brake Co. Over 25 miles of wire, 1300 vacuum tubes and 300 separate chassis assemblies are used in the construction of each S-2B simulator—a control-for-control cockpit reproduction of the all-weather interceptor version of the F-86 Sabrejet.

Used as a trainer for new pilots and a proficiency aid for experi-

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Facts about *HELI-COIL* inserts you should know

What they are

*Heli-Coil** screw thread inserts are precision formed coils of stainless steel or phosphor bronze wire. Wound into tapped holes, they form permanent, non-corrosive, strip-proof threads of astonishing strength. Available for National Coarse, National Fine and Unified threads, pipe threads and spark plug threads. They are made in all standard sizes and lengths for assemblies requiring Class 3, 3B, 2 or 2B fits.

What they are for

AS ORIGINAL COMPONENTS: *Heli-Coil* inserts are used to provide stronger, lighter fastenings, corrosion-proof, wear-proof threads in all assemblies.

FOR PRODUCTION SALVAGE: When conventional tapped holes are damaged in production, restore them on the line with *Heli-Coil* inserts. Get better-than-original strength with no increase in screw size and no tell-tale signs of rework.

FOR SPEEDY REPAIRS: When tapped threads wear, strip or corrode in service, renew them in minutes on location in shop or field with *Heli-Coil* inserts. No welding—no plugging—no secondary machining—no oversize screws.

How they work

Holes are drilled and tapped as you do for ordinary threads—then *Heli-Coil* inserts are wound into tapped holes by hand or power tools. Install in a few seconds, assure thread protection forever. Can be used in any metal wood or plastic.

No other method is so simple, effective and practical.

What they do for you

Heli-Coil inserts *save money* because they strengthen threads and make *fewer* smaller fastenings do the same holding job. They make *lighter* bosses and flanges practical and they *save weight* in two ways: (1) by permitting use of cap screws, instead of bolts and nuts; (2) by allowing use of smaller, shorter, fewer cap screws. *Heli-Coil* inserts *protect* your product from thread wear, galling and stripping for life in every kind of metal, in plastics or wood. They preserve customer good-will by preventing product failure, due to thread fault. *Heli-Coil* inserts improve the end product, cut rejects, salvage threading errors.

Best time to put *Heli-Coil* inserts benefits to your use is right at the designing board, as many leading manufacturers are doing. But to convince you of their many advantages ask for a working demonstration right on your production line. Write today! Complete information and engineering data is available in the *Heli-Coil* catalog. Use Coupon!

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TITANIUM PROP BLADE: Said to be the largest titanium alloy die forging made, this 100 inch long propellor blade is to be used in a special research project for the Air Force. Designed by Hamilton Standard Div., United Aircraft Corp., the blade is forged from Titanium Metals Corp.'s Ti-140-A alloy by the Ladish Co.

enced pilots, the simulator reproduces (with sound effects) almost all conditions and hazards Air Force pilots encounter in ordinary flight and combat.

Training in the simulator is divided into four phases: (1) a transition phase, (2) emergency conditions, (3) navigation with electronic instruments, (4) radar procedures for tracking down enemy planes.

First Speedwalk Will Move Commuter Crowds

Contract to build the world's first passenger conveyor belt system was recently awarded by Hudson and Manhattan Railroad Co. The 227 foot "Speedwalk" to be built by Goodyear Tire & Rubber Co. and Stephens-Adamson Mfg. Co., will be installed in the ramp portion of the connecting tunnel between Erie station and the Hudson and Manhattan tubes at Jersey City.

The system will negotiate a 10 per cent grade on the ramp. The rubber conveyor belt will move at approximately 1½ mph with the two handrails moving at the same speed. Operated by push-button controls, it will be reversible in direction to handle rush hour crowds to and from the tubes.

Although many designs for Speedwalk systems are being made, this will be its first commercial application.

New Agency Handles Material Procurement

Establishment of a Materials Division in the General Services Administration to take over the procurement responsibilities for metals and minerals formerly handled by the Defense Materials Procurement Agency was recently announced. Head of the new division will be Irving Gumbel who had been Acting Deputy Administrator of DMPA which was abolished on August 15.

Objective of the new division, like DMPA, is to increase the potential of scarce metals and minerals. The change is one of internal organization, cutting out unnecessary administrative machinery, Edmund F. Mansure, General Services Administration chief, points out.

"Electronics—Key to Progress" was the theme of the ninth annual National Electronics Conference held in Chicago September 28-30. Record attendance of 6881 visited the 150 exhibit booths. The technical program included 98 papers presented by scientists and engineers from universities, research laboratories and industries.

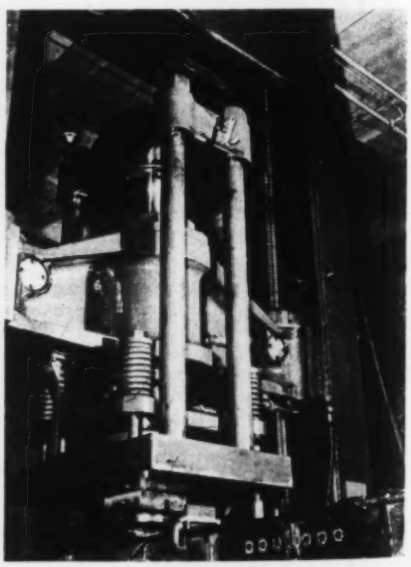
The Conference was sponsored by the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University, University of Illinois, Purdue University, University of Wisconsin, Radio - Electronics - Television Manufacturers' Association, and the Society of Motion Picture Engineers.

Testing Machine Has Unusual Design

A new universal hydraulic testing machine of 400,000 pound load capacity has all power equipment mounted on the crosshead and no part of the machine is below floor level. Installation tests were recently completed by the builder, Baldwin-Lima-Hamilton Corp., at McGill University. The new machine is 22 feet high and has 6½ feet of clear space between columns. Maximum compression space is 12 feet and maximum tension space is 11 feet 2 inches. Stroke is 10 inches.

Test loads are applied downward by a hydraulic cylinder in the crosshead at a maximum rate of 3½

Sensitive crosshead of the new testing machine at McGill University carries all hydraulic and electric equipment to operate the machine. Tensile test loads are applied between the sensitive crosshead and the adjustable crosshead above it. An Emery hydraulic capsule between two plates under the springs transmits load indications to the Tate-Emery indicator dial in the control cabinet



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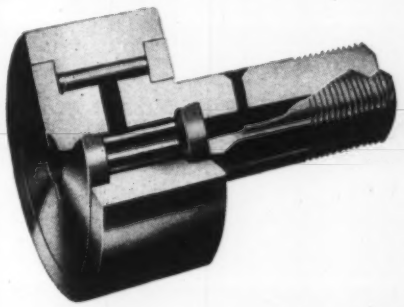
under heavier loads • with shock resistance • and space economy

Modern demands for faster, more automatic machines necessitate a new approach to cam action efficiency. Improvised bolt and roller units are no longer adequate for this mass production machine age.

Machinery manufacturers are finding that even at slow speed, it is difficult to carry the usual heavy radial and intermittent shock loads of cam application efficiently on plain bearings or standard antifriction ball and roller bearings. With increasing speeds, and lubrication limited by the desire for simplified design, the plain bearing wears excessively and fails early. Ordinary ball or radial roller bearings used on a shaft as cam followers have a



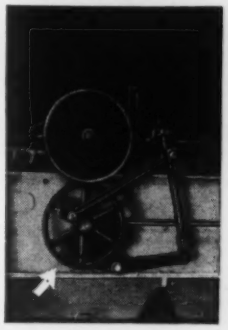
tendency to split in the outer race because of the excessive strain on the thin and superhard race sections.

One bearing that has proven particularly successful in cam follower applications is the Multirol CF series full type roller bearing. This bearing is built especially for the repeated shock loads of typical cam action operations. The outer race section is not only heavy radially but is also martempered to combine maximum toughness with adequate surface hardness for withstanding the punishment of cam applications. The outer ring operates on a full complement of small diameter rollers so the load is evenly distributed over a greater bearing surface. The inner race and flange are made in a single piece with the stud, preventing any possibility of disassembly in operation. Greater accuracy is maintained throughout longer bearing life and, compared with plain bearings, both starting and rolling friction are reduced to a minimum. As a result internal wear is diminished and power requirements of Multirol bearing equipped machines are appreciably lessened.

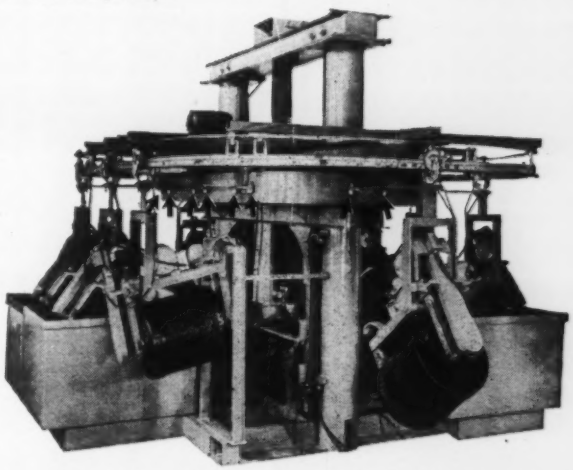
Load Capacity Comparison

To illustrate the increased capacity of the Multirol CF, here is a comparison between a Multirol CF-1 bearing and a corresponding friction type roller, making use of the maximum permissable bearing pressures in pounds per square inch of projected area. The CF-1 bearing will have a maximum of 2240# while the equivalent friction type roller would have a capacity of less than 400#.

What This Means in Terms of Performance

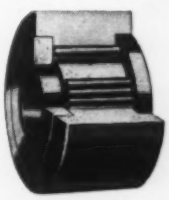


The James Hunter Machine Co., of North Adams, Massachusetts replaced units consisting of a standard roller bearing and hardened roller with Multirol CF bearings on eccentric cams that actuate rake teeth in their wool washers. The changeover reduced their original and replacement costs over 10% and reduced maintenance to occasional lubrication. Where previously, rollers only lasted a maximum of several months, no replacements have been required with the Multirol bearings. As a result, the Multirol Bearings solved a trouble spot that brought in many customer complaints.

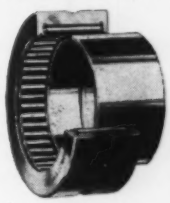


Crown Rheostat and Supply Company of Chicago uses up to 200 Multirol Cam Followers as guide and support rollers in the travel and transfer mechanism of their cleaning, plating, and drying machines. Formerly trolleys were suspended from rails but the cam follower units proved to be a more precision means of friction reduction and added stability to the supporting arms.

Other McGILL® Bearings



MULTIROL CYR



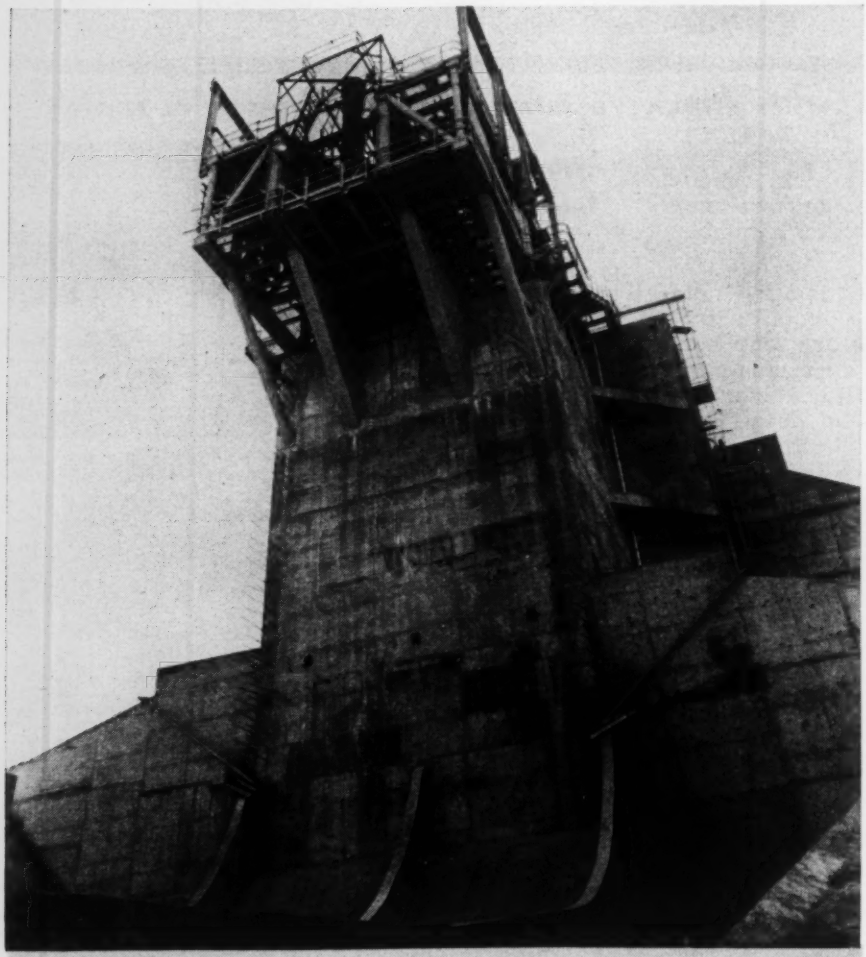
MULTIROL SE

GUIDEROL CT

A new 140-page Bearing Reference Guide complete with 30 pages of vital engineering data has just been released by the McGill Manufacturing Company. It has the full story on the advantages of Multirol CF Bearings as well as information on the Multirol CYR, Multirol SE and Guiderol Bearings. Send now for your copy of McGill Catalog No. 52.

McGILL® — Precision Bearings

McGILL MANUFACTURING COMPANY, INC.
200 N. Lafayette Street, Valparaiso, Indiana



ROCKET RESEARCH: This impressive concrete and steel structure is a static test stand for rocket engines. To withstand tremendous thrust of test engines, footings penetrate as deep as 60 feet into solid granite. Several of these huge test stands, rocket propellent tanks and various buildings located near the center of the Mojave Desert make up the Air Force Experimental Rocket Engine Test Station

inches per minute. A small piston is used to return the drive head to starting position. Crosshead positioning is performed by two motor-driven nuts rotated on vertical screws in the columns.

Loads are measured by a separate hydraulic system operated by an Emery hydraulic capsule on the sensitive crosshead. Flexible tubing connects this capsule with a Tate-Emery indicator in the control cabinet. The indicator has three full-scale ranges: 0-20,000, 0-100,000, and 0-400,000 lb. Accessories include a pacing disk on the dial which permits applying loads at predetermined constant speeds, and a load maintainer which permits holding load constant for long periods of time. The cabinet is designed so that any of the newer types of stress-strain recorders may be used with it.

A new jet engine has just completed the Defense Department's 150-hour qualification test which is the equivalent of 75,000 miles of actual flight. Designed for use in high-speed military fighter planes, the new Westinghouse J-46 engine will be first used in the new swept wing, tail-less Chance-Vought F7U-3 Cutlass, one of the Navy's latest carrier-based fighters.

An outgrowth of the well-known J-34 engine, the high-power, low-weight J-46 is 16½ feet long and less than three feet in diameter. It weighs approximately 2000 pounds.

Purdue Holds Graphics Conference

To discuss, demonstrate and exhibit the applications of graphical methods in engineering, the Department of General Engineering of Purdue University is holding a conference on Friday, November 20. Reproduction processes, graphical methods for solving problems, manual and automatic computing devices, realistic delineation or drawing of parts and assemblies, and graphic data presentation and recording will be considered.

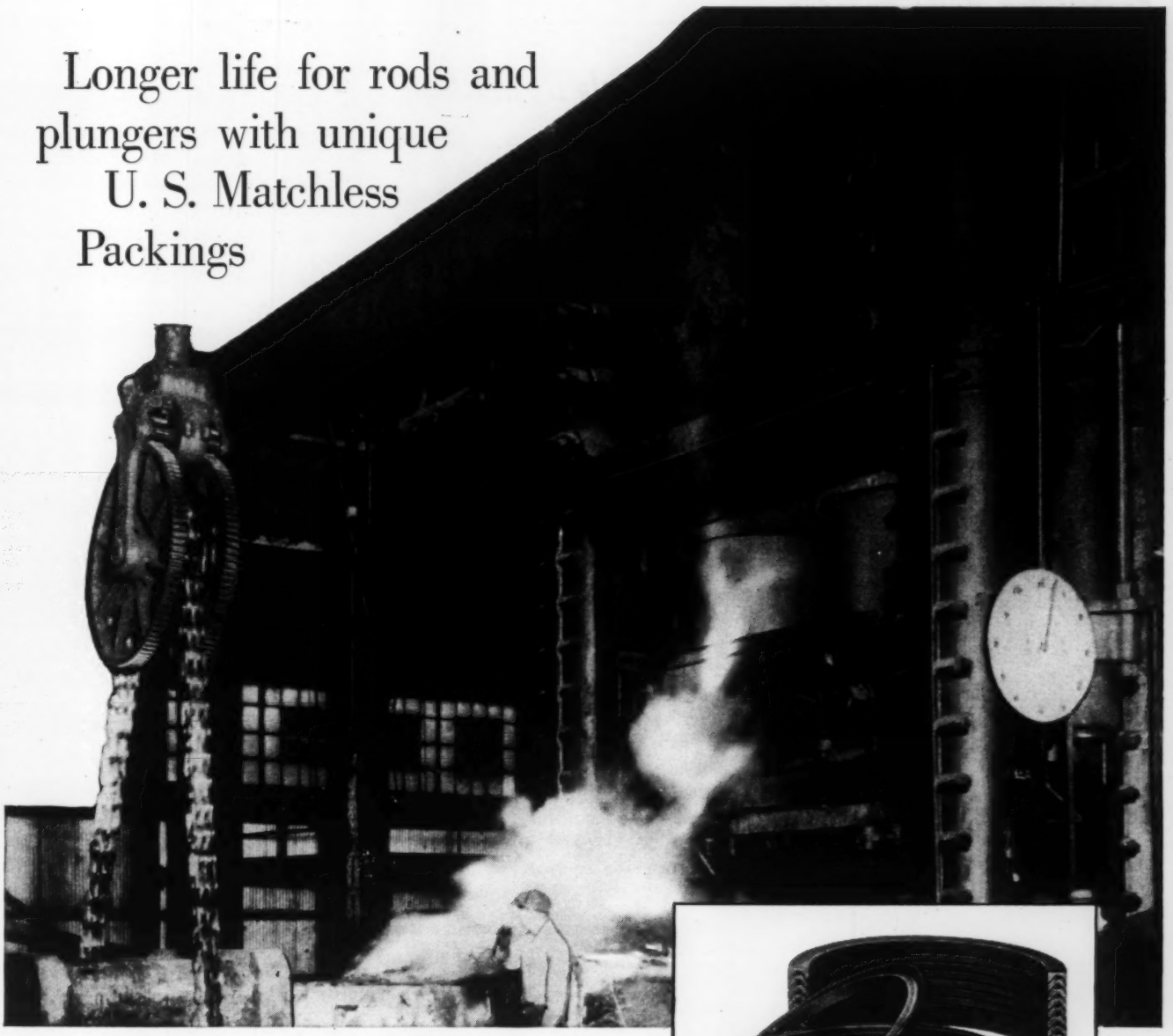
Further information on the conference may be obtained from: Division of Adult Education, Engineering Administration Building, Purdue University, Lafayette, Ind.

Rust-Proof Process Said to Equal Plating

Ferrous metals treated by a new low-cost chemical immersion method are said to show durability in salt-spray tests previously obtainable only with electroplated coatings. Products treated by the process are reported to withstand salt-spray tests from 12 to 24 times as long as those treated by standard phosphate coating methods. Called "Endurion," the treatment, developed by Rust-Proofing and Metal Finishing Corp., can be applied in integral colors ranging from black and gray to blue, green and olive drab.

Uniform protection of every surface the treating fluid can reach is said to be provided by the process, even on parts with complicated shapes and deep recesses. Additionally, threaded parts can be protected without "build-up."

Longer life for rods and plungers with unique U. S. Matchless Packings



U. S. Matchless Packing comes in 12 different styles, to handle pressures up to 8,000 lbs. per square inch.

No other packing has *all* these advantages:

- **Blunt edges**—provide uniform strength throughout.
- **Triangular spaces**—to trap loose scale, oil.
- **Pressure break**—provides faster, more effective action.
- **Molded end rings**—no sharp edges to break off.
- **Easy to install**—because of parallel (not flare type) side walls.

Matchless® Packing reduces wear and tear on rods and plungers, minimizes friction because it has a self-adjusting, automatic action. Designed for hydraulic equipment, presses, rams, triplex pumps and outside packed pumps. This *quality* U. S. Matchless Packing is stocked at any of the 25 "U. S." District Sales Offices—each staffed with engineers—and distributed by wholesalers everywhere. Or write to address below.

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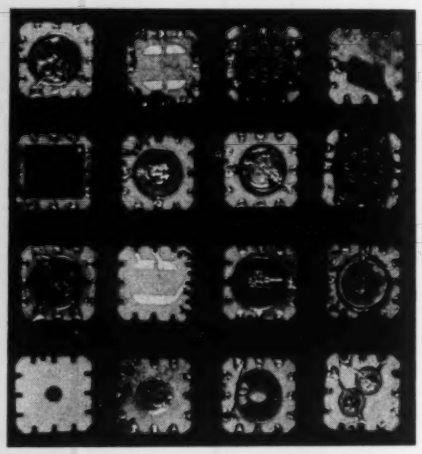
Three-D Printed Circuits Produced Entirely By Machine

An automatic production line for the manufacture of electronic products, and a novel system of electronics design which makes this possible, have been developed by the National Bureau of Standards. The program, code-named Project Tinkertoy, was sponsored by the Navy Bureau of Aeronautics.

Starting from raw or semiprocessed materials, machines automatically manufacture ceramic materials and adhesive carbon resistors,



A few of the various types of wafers produced in the mechanized electronics assembly plant. Tube sockets, coils, toroids, potentiometers and crystals are among the wafer-mounted parts

print conducting circuits, and mount resistors, capacitors, and other miniaturized component parts on standard uniform steatite wafers, ⅞-inch square by 1/16-inch thick. The wafers are stacked very much like building blocks to form a module that performs all of the functions of one or more electronic stages. Automatic inspection machines check physical and electrical characteristics of the parts-mounted wafers at numerous stations along the production line. The completed module is a standardized, interchangeable subassembly combining all of the requirements of an electronic circuit with ruggedness, reliability, and extreme compactness.

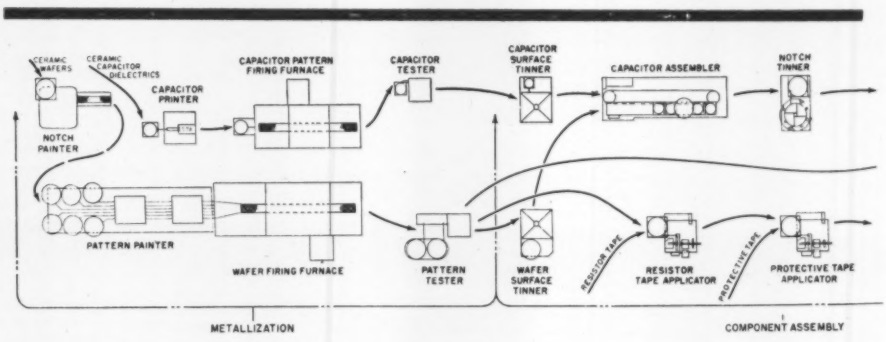
The standard wafer is pressed with twelve peripheral notches (three on a side) and a keying notch on one side. In the final module assembly, riser wires are mechanically soldered into the twelve notches and serve as physical supports for the module and electrical connectors between wafer-mounted circuits. The keying notch is a medium by which individual wafers are automatically oriented for the mechanical application of component parts.

Titanate capacitor bodies are manufactured in much the same manner as the ceramic wafers. The capacitor is nonporous ceramic composed usually of magnesium, barium, calcium, and strontium titanates of high purity, organic binders and water. After firing, it is about ½-inch square and 0.02-inch thick. The capacity values may be varied from 7.0 micromicrofarads to 0.01 microfarad by changing the relative proportions of the constituent minerals. Raw material batches weighing about five pounds will produce about 100,000 capacitors.

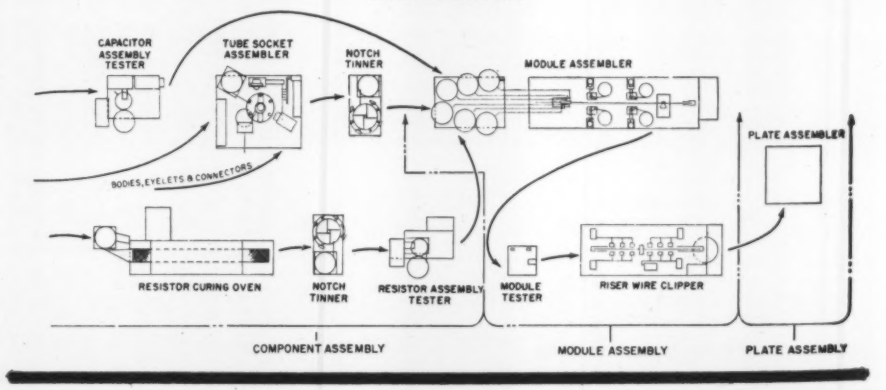
Appropriate sections of the wafer or capacitor body are silver coated by metallizing. During these stages, circuits are printed on the wafers, notches are coated, conducting surfaces and leads are applied to capacitors, furnace-curing takes place, and circuits are inspected. Finally, all silvered surfaces receive a thin coating of solder. All of the operations are mechanized.

Tape resistors, titanate capacitors, tube sockets, and other miniaturized parts are mounted on the wafers between the appropriate silvered conducting patterns after metallizing. Rolls of resistor tape are placed on a machine that automatically cuts the tape into one-half inch lengths, presses the resistors between the printed electrodes on the surface of the wafer, applies pressure, and ejects the completed resistor- mounted wafer. As many as two resistor tapes may be applied to each wafer surface.

After the various parts have been mounted on the wafers, the notches on the wafer are tinned with solder. The machine that performs this operation automatically grips each component-mounted wa-



Schematic diagram of the Project Tinkertoy mechanized assembly line shows the steps required to produce a complete electronic assembly from the various raw materials



DOW

MAGNESIUM FINDS INCREASING FAVOR AS DIE CASTING METAL

Advantages of light weight, easy machinability and competitive cost make Magnesium preferable for many types of die castings

Many manufacturers are taking a new look at magnesium as a die casting metal. In today's competitive markets, magnesium offers advantages that can't be overlooked.

Take light weight. Magnesium is the world's lightest structural metal. Where weight is a competitive factor, magnesium is the metal to use. A manufacturer of portable electronic dictation equipment found that nineteen castings in zinc weighed 13 pounds, 6½ ounces; and *in magnesium, 3 pounds, 10 ounces.* That's real weight saving!

Magnesium is well known as the easiest of all metals to machine. This in itself promotes economy. As an example, the manufacturer of a lubricating machine found that the cost of machining an oil reservoir cast in grey iron was $2.05 while machining the same part cast in magnesium cost only 80¢.

Cost-wise, magnesium is better than competitive in numerous applications. One large automotive manufacturer (an industry where cost is figured on a fractional basis) has found magnesium die castings to be the lowest in cost of any metal in a score of applications. Moreover, magnesium's long-time record of price stability is also an important factor.

Now's a good time to take a close look at magnesium. For the competitive markets ahead, magnesium can offer you many advantages. Your nearest Dow office can give you up-to-the-minute information. Or write THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan.

you can depend on DOW MAGNESIUM

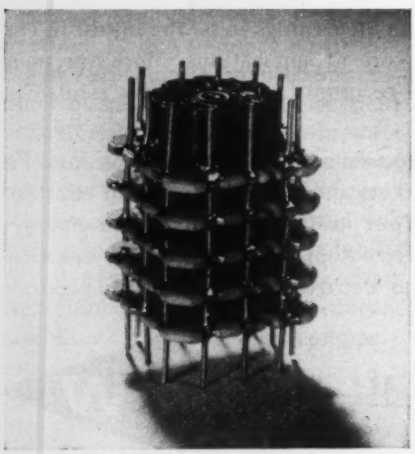
DOW

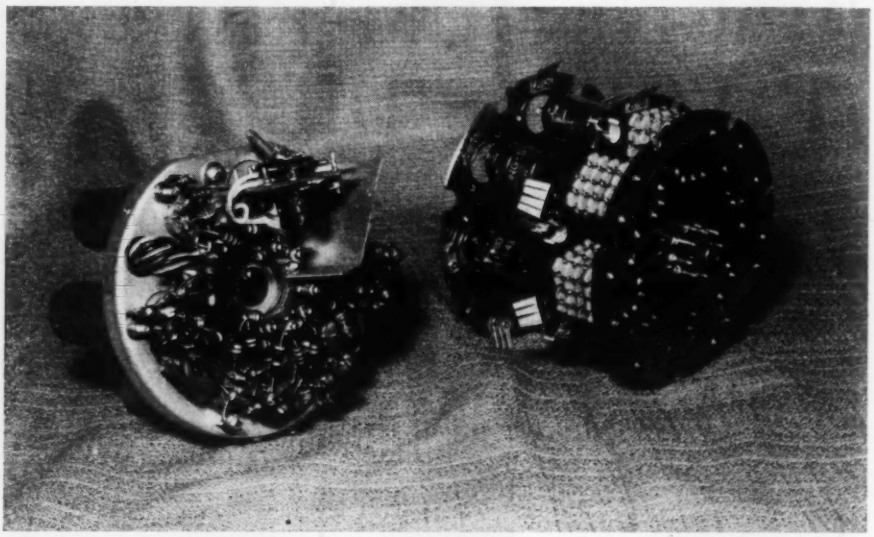
fer and dips one side into flux and solder. The tinning operation is repeated on the other three sides after successive 90 degree-turns of the wafer.

Uniform wafer-mounted component parts, including wafer-mounted coils, toroids, potentiometers, and crystals are now ready for assembly. The complete assembly of the module is accomplished in a single machine. Six vibratory feeders issue the wafers to a loading device that holds the wafers in an upright position between specially designed jaws. A chain drive carries the jig to a soldering position at which six riser wires are guided into appropriate notches, three on a side. The mechanism brings soldering irons in contact with the unit and bonds the wires to the notches. The unit is turned 90 degrees, and the chain drive carries it to another soldering position where six more wires are bonded to the module. After final electrical inspection, segments of riser wires are severed where circuit isolation is required between wafer-mounted circuits.

Final assembly operation need not necessarily be considered a part of the mechanized production of electronics. Normally, a set of modules (as many as ten) are mounted on or between copper-clad base plates. Circuits etched into the copper surfaces connect the riser wires of the several modules to form a complete electronic circuit. Several such plate assemblies may form an equipment. One base plate with six modules, for instance, contains all the necessary circuits to make a six-tube radio receiver function properly.

Completed module consists of the required number of wafers joined by 12 riser wires. Riser wires are automatically cut after assembly to provide circuit isolation where required





Modules are mounted on or between copper-clad base plates. Circuits etched into the copper surfaces connect several modules to form a complete electronic circuit. Conventionally or hand-assembled equivalent is shown, left, for comparison

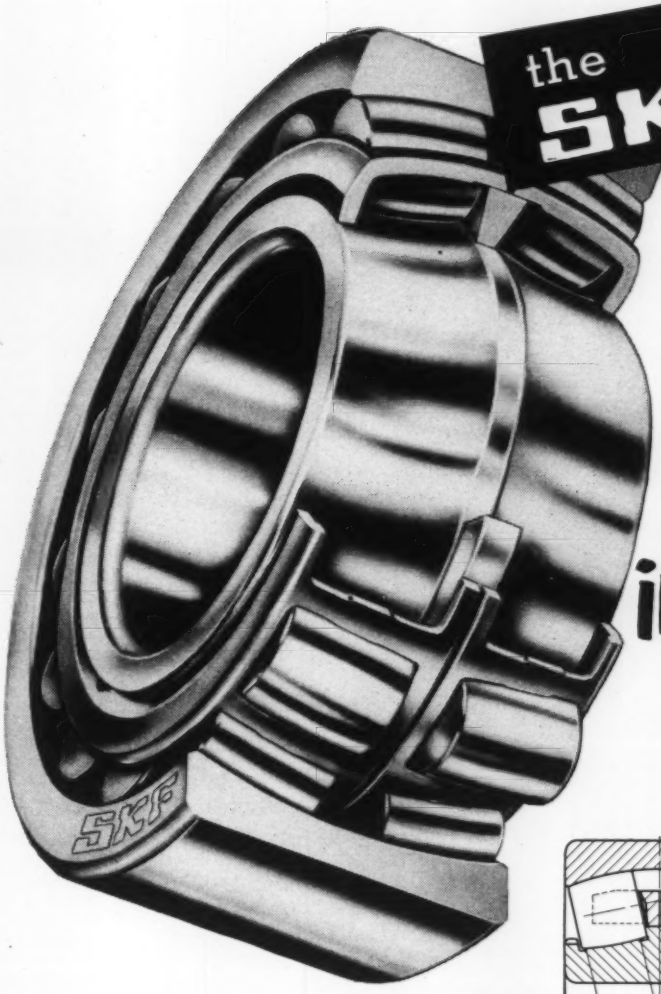
Performance of equipment produced in Project Tinkertoy appears generally equivalent to that obtainable from conventional assemblies. Equipment produced on an experimental basis meets military environmental requirements, passing such tests as shock, vibration, temperature, and humidity established in military specifications. Moreover, the standardization and uniformity achieved by the wafer-component and stacked-wafer design result in production outputs of uniformly satisfactory equipment, whose characteristics both physically and electrically are carefully controlled through the 100 per cent automatic inspection machines that are an integral part of the production line.

While some of the plant machines were designed and constructed by NBS, the major part of the design and construction of the production equipment was done by the Kaiser Electronics Division of Willys Motor Co. Some special machines were also designed and built by the Doughnut Corp. of America. Specially designed automatic production test equipment was obtained principally from Communication Measurements Laboratory, Inc. Some major engineering applications to equipment were made by Sanders Associates, Inc. including environmental studies of units. The Davies Laboratories (Riverdale, Md.) and the Navy Post Graduate School (Monterey, Calif.) also rendered assistance in some phases of the work.

West German Tool Plants Said To Be Best-Equipped

West Germany now seems to have the best-equipped machine tool plants in the world, according to an American executive recently returned from a three-month tour of industrial plants and research laboratories in ten European nations. The new machinery in one plant includes boring and turning equipment which will accommodate parts over 52 feet in diameter —equipment probably unequalled anywhere in the world.

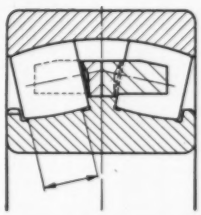
Christy A. Wiken, vice president of research and engineering, Rockwell Mfg. Co. reported that leading German machine tool manufacturers have replaced bombed-out



improvement of internal design of spherical roller bearings

Increases capacity 25% to 50%

increases service life 2 to 3½ times

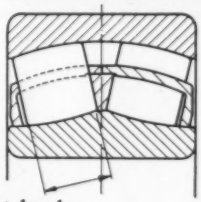


This is the Spherical Roller Bearing design originated by SKF *more than 30 years ago.* The cross-section shows how the integral inner ring flanges, and the undercuts adjacent thereto, limit the effective length of the rollers.

Now, SKF, originator of the Spherical Roller Bearing, has again provided industry with another anti-friction *first.*

This time, it's a revolutionary design advance in Series 222 and 223 bearings providing these advantages:

When designing new equipment, you can obtain the desired life by using smaller or lighter bearings at considerable cost saving. In addition, this forward step in design will carry heavier combinations of radial and thrust loads, or pure thrust loads of greater magnitude. The important self-aligning feature of SKF Spherical Roller Bearings has been preserved, so that considerable misalignment between the shaft and housing has no ill effect whatever on bearing capacity or life.



Here is the latest SKF improvement, a *revolutionary advance in design.* Effective roller guiding is accomplished by means of a separate ring. The need for undercuts is eliminated! This type of guide ring permits the rollers to take the position which their contact with the rings dictates. This assures uniform load distribution over the entire length of the longer rollers at all times. *Result*—greatly increased capacity and life.

During more than 4 years, thousands of installations have been made in railroad journals, vibrating screens, steel mill machinery and numerous other fields. In all cases performance has been outstanding.

SKF Sales Engineers in our District Offices throughout the country will assist you in making use of the important advantages of the improved internal design of SKF Spherical Roller Bearings. **SKF INDUSTRIES, INC.,** Dept. 616, PHILADELPHIA 32, PA.
— *manufacturers of* **SKF** *and* HESS-BRIGHT *bearings.*

7424

This 12-page booklet gives you additional facts—sizes available—added capacity, size by size—increased life you can expect for each size—dimensional tabulations—and load and speed data. Write now for your free copy of Booklet No. 365-2.

SKF®
BALL AND ROLLER BEARINGS

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plants and ruined machinery with equipment incorporating the most advanced design ideas. The new facilities eliminate many of the old evils of inadequate plant layout and machinery for up-to-date metal-working processes.

However, the industry is suffering from a severe slump in orders, according to Mr. Wiken. Possibly the Germans have overestimated the market for machine tools—or underestimated the competition from other nations.

WORLD'S LARGEST DREDGE: The 26-ton spiral bladed cutter head of this dredge, driven by a 1000-horsepower dc motor, digs heavy boulders and sticky clay with no preliminary blasting. Boulders weighing as much as 1500 pounds can be handled. An estimated $500,000 of General Electric apparatus is used on the 280-foot vessel which is cleaning a 15 mile long, 3300 foot wide and 35 foot deep channel in the Beauharnois Canal between Lake St. Francis and Lake St. Louis in Quebec

Improved Bearing Has Increased Capacity

With no change in size or weight, a capacity increase of 25 to 50 per cent and service life 2 to 3½ times longer are claimed for an improved design of spherical roller bearing. Service tests of thousands of the bearings over a long development period have been successful in applications such as railroad journals, vibrating screens and steel mill machinery according to the manufacturer, SKF Industries Inc.

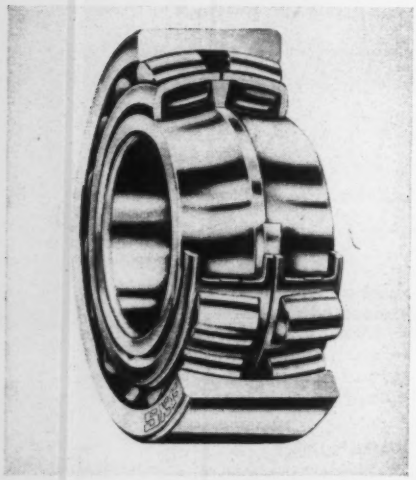
The inner race of the improved "C" type bearing is a new design without undercuts and integral flanges. Its capacity is increased because longer rollers are used, with more effective contact between rollers and rings, in the larger area provided by the new design. A separate guide ring, between the two rows of rollers, allows them to take the position which their contact with the rings dictates. Load distribution is uniform at all times and greatly increased capacity and life result.

Each row of rollers is held in a window-type cage made of high-tensile-strength, cold rolled brass. Mechanically, the cage is strong and well supported. Even when used in applications where stresses upon the cage are most severe, such as the eccentric locations in shaker screens, trouble-free operation is claimed. Each cage centers on two large areas, one directly on the inner ring—outside of the rollers—and the other on the OD of the guide ring.

Where combined loads are present, the improved spherical bearing is capable of carrying heavy combinations of radial and thrust loads, or pure thrust loads of greater magnitude.

The important self-aligning feature of previous bearings has been preserved, so that considerable misalignment between the shaft and housing has no ill effect on bearing capacity or life.

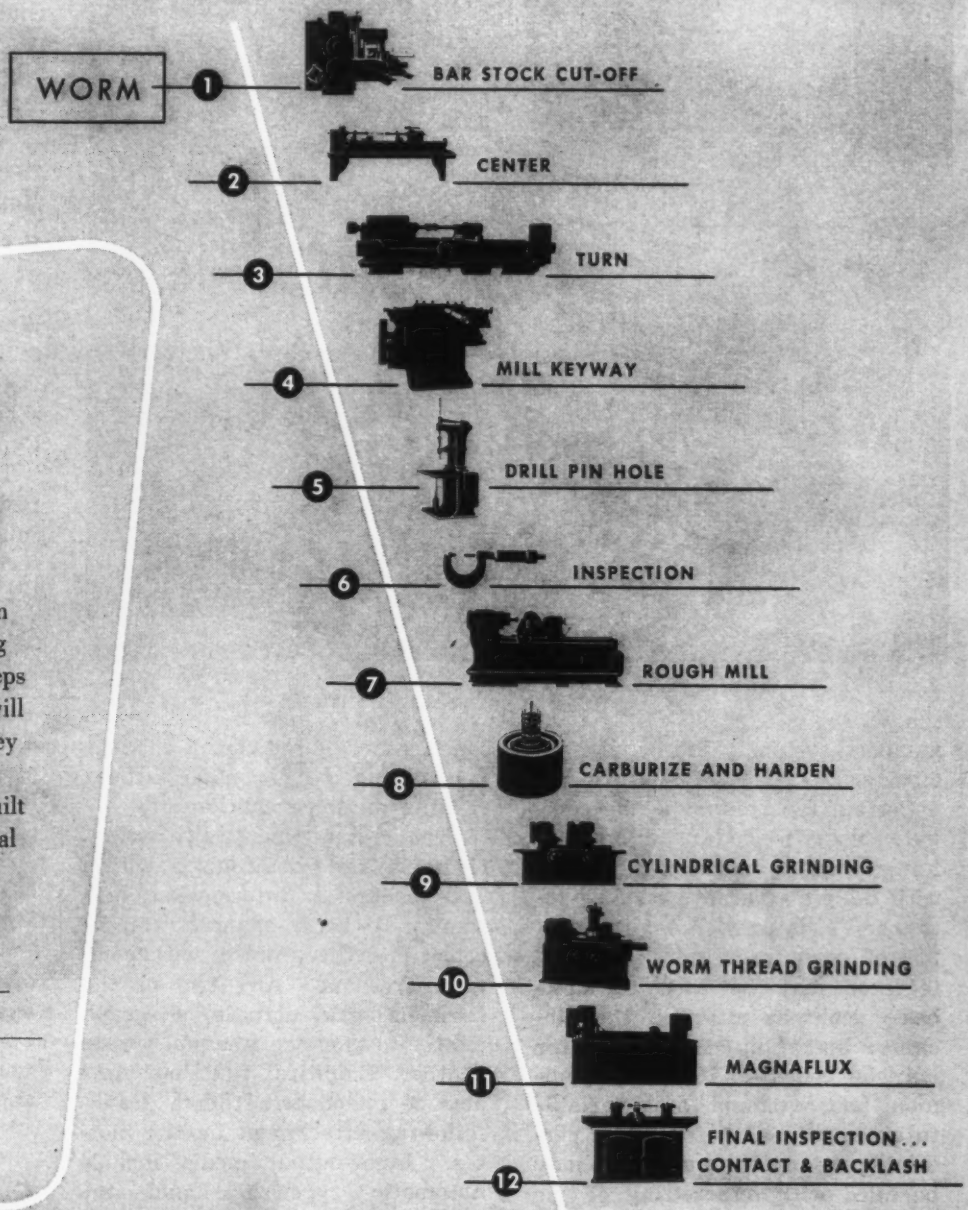
Improved spherical roller bearing has higher capacity and longer life



First Decimal Digital Differential Analyzer

A new electronic computer is said to be the world's first decimal digital differential analyzer. The computer will automatically solve any problem which can be written as an ordinary differential equation as well as some partial differential equations. Operation in the decimal number system, instead of the binary system, plus the initial storage system is said to make the Computer Research Corp. machine as easy to fill as operating a standard ten-key adding machine, and to reduce filling time by 75 per cent over binary

Facts you should know about DE LAVAL *worm gearing*



17 steps to quality sets

Here's proof of precision manufacturing and quality control in the production of worm gearing at De Laval. These 17 major steps result in worm gear sets that will take long punishing service. They are your assurance that these De Laval units are built to be built into quality products. • De Laval manufactures a wide range of heavy duty worm gear sets:

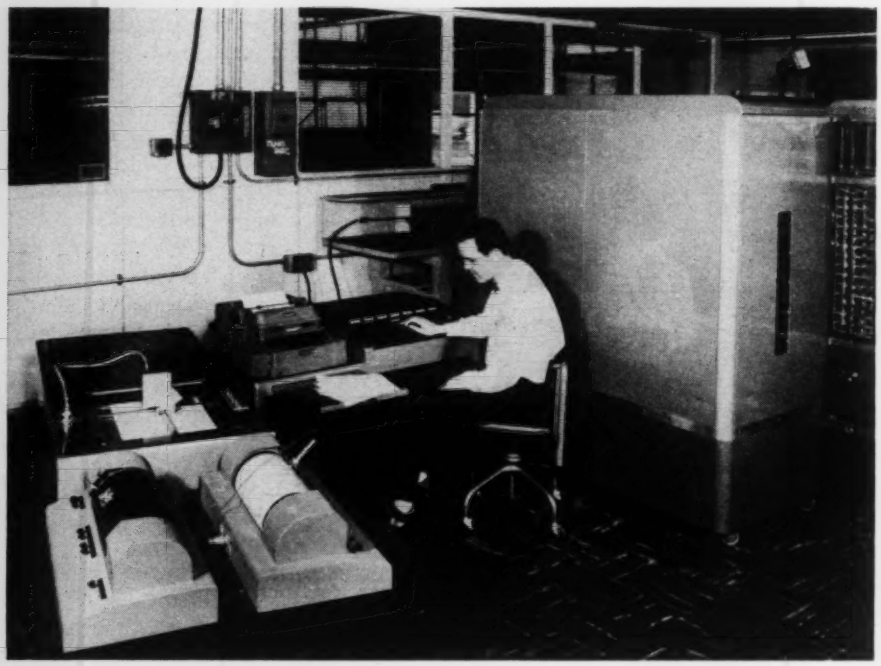
Ratios	**3:1 to 100:1**
Ratings	**.1 hp to 550 hp**
Center distances	**3″ to 36″.**

A NEW WORKING TOOL FOR YOU!
Worm Gear Sets Catalog 5000 contains 38 pages of vital data. Write for your copy on your business letterhead.

DE LAVAL *Worm Gear Sets*

DE LAVAL STEAM TURBINE COMPANY
858 Nottingham Way, Trenton 2, New Jersey

DL223



number system differential analyzers.

Certain features make the computer easy to code and operate. For example, a constant multiplier with 6-digit accuracy, varying between ± 1, is provided at the output of each integrator. Any integrator may be used to make basic decisions affecting the machine's operation. Any integrator may be coded to limit the minimum and maximum of a variable to given values. Information pertaining to any one integrator may be filled with one setting of the integrator switch.

Speed of the machine enables 60 increments of the independent variable to be computed every second. A recently discovered application is the solution of partial differential equations with boundary conditions by relaxation methods. A similar application is the solution of any set of linear algebraic equations of order 7 and less.

Its capacity is the largest of all digital differential analyzers, having sixty integrators with a maximum accuracy of six digits and sign in each integrator. It will remember all initial conditions of a problem and will restore itself to the initial state at the touch of a button on the control console. This feature permits small changes in a problem to be made without refilling all the conditions.

Twelve input and twelve output channels are synchronized within the machine. Information pertaining to these channels can be coded into the problem with complete freedom. Any two of the channels can actuate a graph plotter to plot one function versus another. Empirical functions may also be introduced from a graph-following attachment on the plotter. Input-output media include automatic typewriter and the graph plotter and follower.

The five machines being built will be used by government and military organizations working on trajectory, net relaxation, interior ballistics and aerodynamic problems, and dynamic system analysis.

Zirconium strip and shape production for atomic energy applications is being expanded by Allegheny-Ludlum Steel Corp., the first private company to undertake melting zirconium sponge into ingot form. Although the melting process involves two steps and careful control to maintain required high purity, processing from the ingot stage is done on regular mill equipment. In general, the company feels that any product normally produced on steel mill equipment can be made.

New Administration For Business, Defense Services

Secretary of Commerce Sinclair Weeks recently announced the establishment of the Business and Defense Services Administration, a primary organization unit in the Department of Commerce.

The new agency continues the residual defense and mobilization functions authorized by law of the former National Production Authority; consolidates five current departmental offices; establishes 25 industry divisions, staffed by business experts from government and private industry, and provides a focal point for effective co-operation between government and business in promoting economic stability and growth.

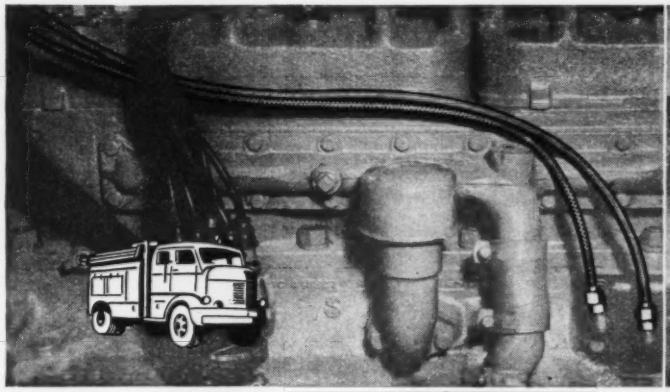
The offices transferred to the BDSA are: the Office of Technical Services, the Office of Distribution, the Field Service, staff functions of the Industry Evaluation Board, and the Office of Industry and Commerce, including its Trade Association, Commodities Standards and Area Development Divisions.

Fuel Tank Gets Belt on Back

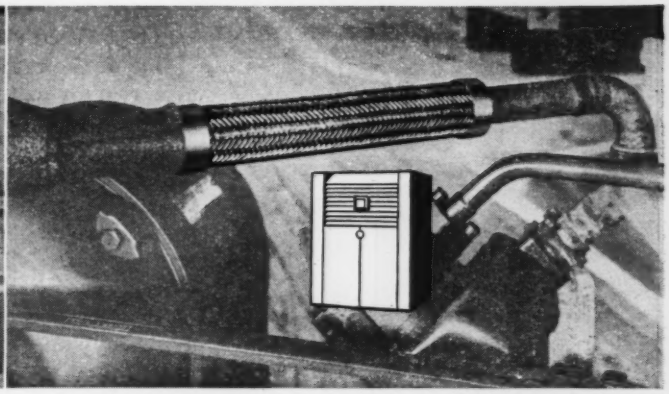
Jettisonable aircraft fuel tanks and other components are given a big squeeze by a series of belts or flexible load straps on a unique static test stand at Pastushin Aviation Corp. A development of the firm's research and development engineering staff, the test stand is adjustable to accommodate any size external fuel tank or streamlined shape.

A strong welded and bolted frame, hydraulic system for loading, a series of load straps to apply the loads and dynamometer rings for measuring loads make up the stand. Resultants of vertical and horizontal inertia as well as

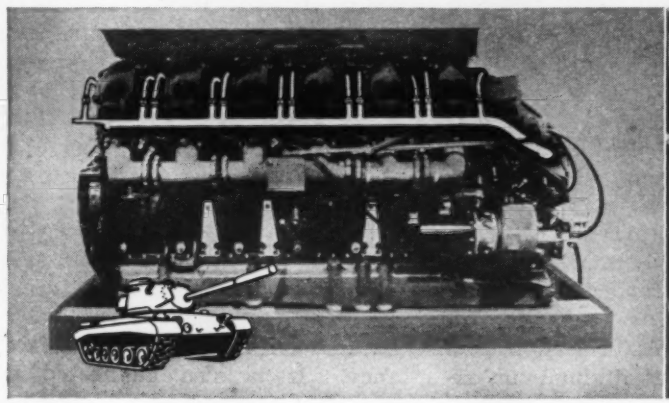
These 4 may end your design worries, too



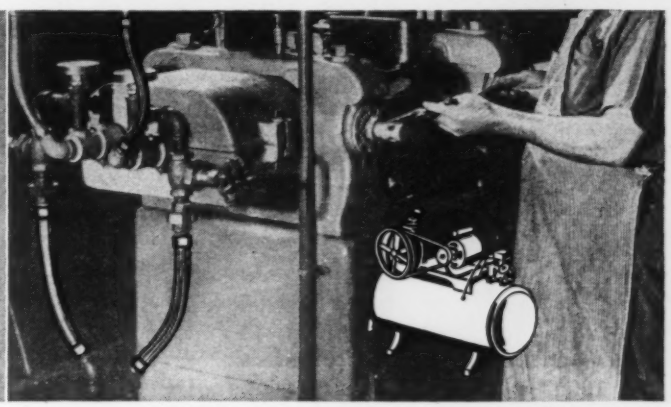
END FUEL LINE FAILURE. Four Wheel Drive's famous trucks stand up to roughest service. So do their Titeflex® oil and fuel lines. Automotive engineers specify Titeflex metal hose because it resists wear, vibration and corrosion —won't crack, bake or deteriorate under high engine temperatures.



ELIMINATE VIBRATION. To end vibration and prevent leaks around fittings, Uniflex seamless metal hose is installed between circulator coils and motor of GE's packaged air-conditioning unit. Made by Titeflex, Inc., Uniflex withstands critical stress and strain—is inherently leakproof.



BANISH IGNITION TROUBLE. Neither mud nor dust, snow, water or lubricants can affect the Titeflex-protected ignition leads of Continental engines in Patton M-48 Tanks. Also suppresses radio interference. Titeflex is a leader in developing ignition harnesses and metal hose lines for Army Ordnance tanks and vehicles. Titeflex quality pays off here.



CONVEY CRITICAL FLUIDS SAFELY. Cooling lines to rubber milling machine use flexibility of Titeflex to advantage. In other applications, tough, corrosion-and-wear-resistant Titeflex safely conveys oil, steam, gases, lubricants, brine, acids, oxygen and compressed air. Rugged, seamless Uniflex withstands extreme vibration, physical abuse and strain.

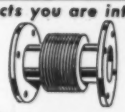
THERE'S ALMOST NO END to the engineering uses for Titeflex® seamed flexible metal hose or Uniflex seamless metal hose. From aircraft to automotive equipment—from drain lines to dental units—Titeflex simplifies design, construction, operation and maintenance. For types of hose, fittings, assemblies, applications and engineering data, keep our *new 48-page Metal Hose Catalog* No. 200 at your elbow. Use the coupon below to bring it and our design service without delay.

Let Our Family of Products Help Yours

Titeflex

✓ Check products you are interested in.

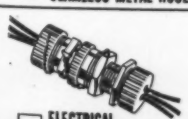
☐ SEAMED AND SEAMLESS METAL HOSE



☐ PRECISION BELLOWS

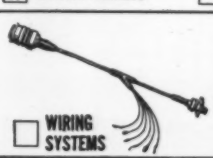
☐ IGNITION HARNESS

☐ IGNITION SHIELDING

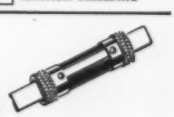


☐ ELECTRICAL CONNECTORS

☐ RIGID AND FLEXIBLE WAVE GUIDES



☐ WIRING SYSTEMS



☐ FUSES

TITEFLEX, INC.
508 Frelinghuysen Ave.
Newark 5, N.J

MAIL COUPON TODAY

Please send me without cost information about the products checked at the left.

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TITLE_____

FIRM_____

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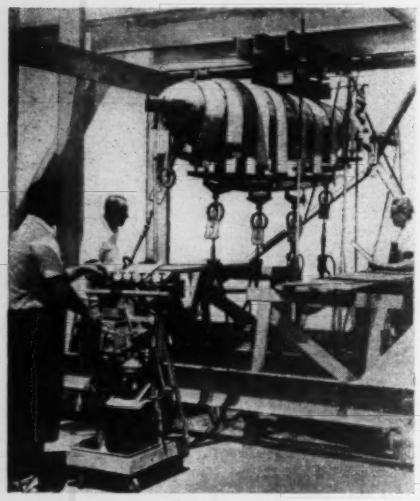
CITY_____ ZONE____ STATE_____



Unique test stand uses flexible straps for distributing test loads in static tests of external aircraft fuel tanks

aerodynamic loads resulting from flight maneuvers are distributed over the length of the structure being tested by the flexible loading straps. Applied loads are measured at two airload and ten inertia load points by the dynamometer rings. Present tests simulate sonic and transonic flight conditions resulting in applied loads from 8 to 16 tons and coresponding skin loads to 1600 pounds per square foot. Additional capacity will permit application of loads as high as 20 tons for static testing components designed for supersonic speeds.

Contract Completed For First University Reactor

First university-owned nuclear reactor in the nation will soon be in operation at the North Carolina State College, Raleigh, N. C. Under contract with the Atomic Energy Commission, the AEC will loan the College enough fissionable uranium 235 to fuel the "Raleigh Research Reactor" recently constructed in a new building on the campus.

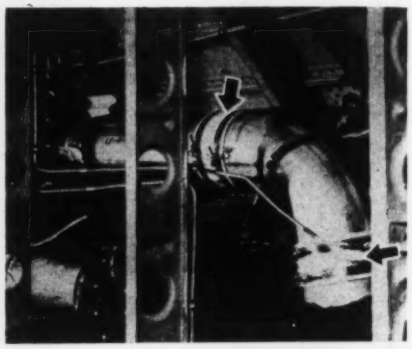
The reactor assembly is complete and most of the preoperational testing has also been completed. Loading of the fuel and initial operation will begin as soon as the fissionable material is received. Provision of the fuel for the new reactor culminates a project under way since June, 1950, when the College, under contract to AEC, initiated design and construction of a low-powered research reactor.

One of the major purposes of the new reactor will be to supply reactor experience to students in nuclear engineering—a new curriculum initiated in 1950. A program of research on the reactor itself is scheduled for the first year of operation, after which emphasis will shift to use of radiations and radioactive isotopes produced by the reactor in numerous research activities of the College and neighboring institutions.

First educational institution to approach the Commission with a plan to design, build and operate a research reactor, North Carolina State's proposal was the first approved by the AEC.

Hi-Temperature Rubber Joins Heater Ducts

Heater ducts carrying air at a temperature higher than the melting point of solder are being coupled with a new flame-retardant silicone rubber. Every bend in more than 40 feet of aluminum ex-



Glass cloth flanges (arrows) are coated with General Electric's flame retardant SE-101 silicone rubber to withstand the 600 F temperatures of heater ducts in Consolidated Vultee Aircraft's Convair Liner

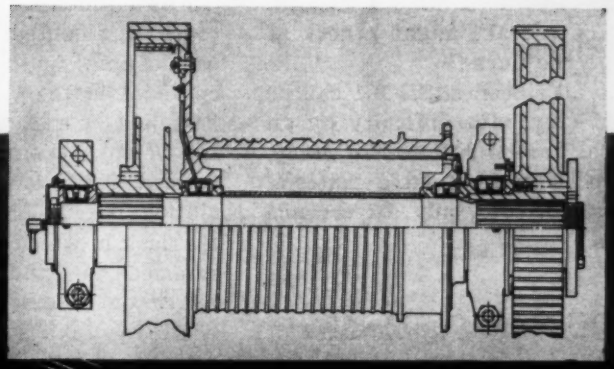
haust ducting in the Model 340 Convair-Liner is made flexible with glass cloth connectors coated with General Electric's silicone rubber.

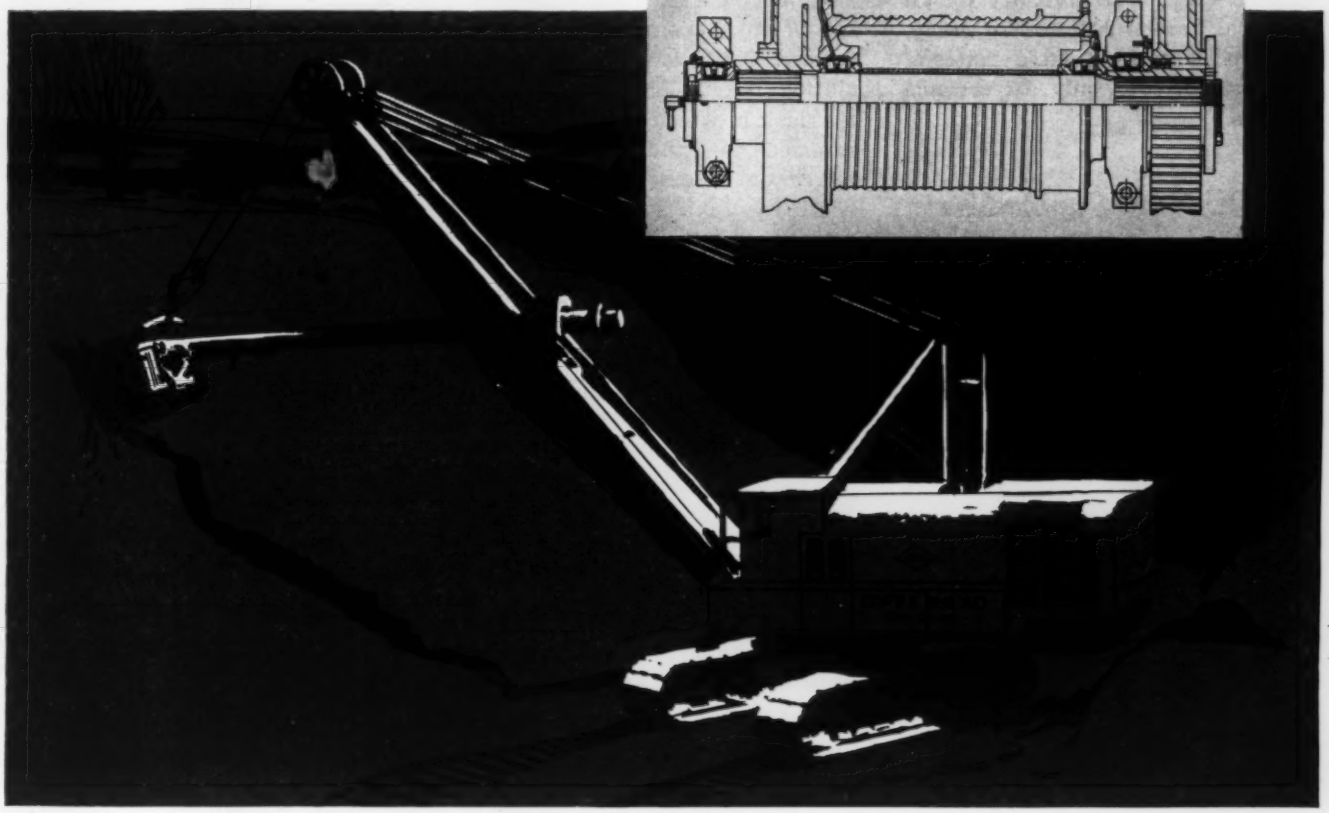
According to the makers of the twin-engine passenger liner, the ducts carry air at 450 F and are designed for temperatures as high as 600 F. The new silicone was selected for its ability to withstand this heat as well as for its excellent crease and abrasion resistance and unusual flame retardancy. It is also unaffected by

TITANIC TANDEM helicopter is 134 feet long including rotor overhang at each end. Actual fuselage length is 78 feet while twin rotors are each 82 feet in diameter. Powered by two Pratt & Whitney engines with ratings of 1650 horsepower, this Piasecki YH-16 is the Air Force's newest. First flight of the 40-passenger helicopter is predicted for this fall

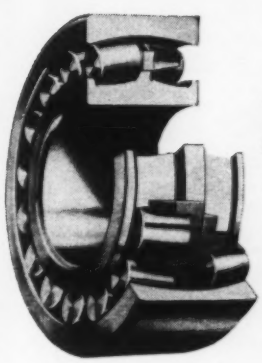
TORRINGTON BEARINGS AT WORK

For smooth, low-maintenance service under toughest operating conditions, both front and rear hoist shafts on the 479,000-pound LIMA Type 2400 power shovel are equipped with precision-ground TORRINGTON Spherical Roller Bearings.





Friction defeated!



Power delivered!

The bite of the bucket into solid earth may cause deflection, but TORRINGTON Spherical Roller Bearings, self-aligning and with high capacity, keep right on rolling. Power is constant and your shovel stays on the job.

These rugged friction fighters are made from the finest of bearing steels, carefully heat treated for maximum strength, toughness and resistance to wear. Both rollers and races are accurately manufactured for geometrical conformity and highest load-bearing capacity at all times. The solid ring, cast-bronze cages are *land-riding*.

TORRINGTON Spherical Roller Bearings cut operating costs in the toughest of earth-moving and rock-processing applications. Prove it to yourself—specify TORRINGTON.

THE TORRINGTON COMPANY
South Bend 21, Ind. Torrington, Conn.

TORRINGTON SPHERICAL ROLLER BEARINGS

Spherical Roller • Tapered Roller • Straight Roller • Needle • Ball • Needle Rollers

Skydrol hydraulic fluid which, in event of a leak, might otherwise damage the ducts.

Like all silicones, SE-101 can be ignited only with difficulty by an external flame. But unlike many, this specially formulated material supports fire for only six seconds or less.

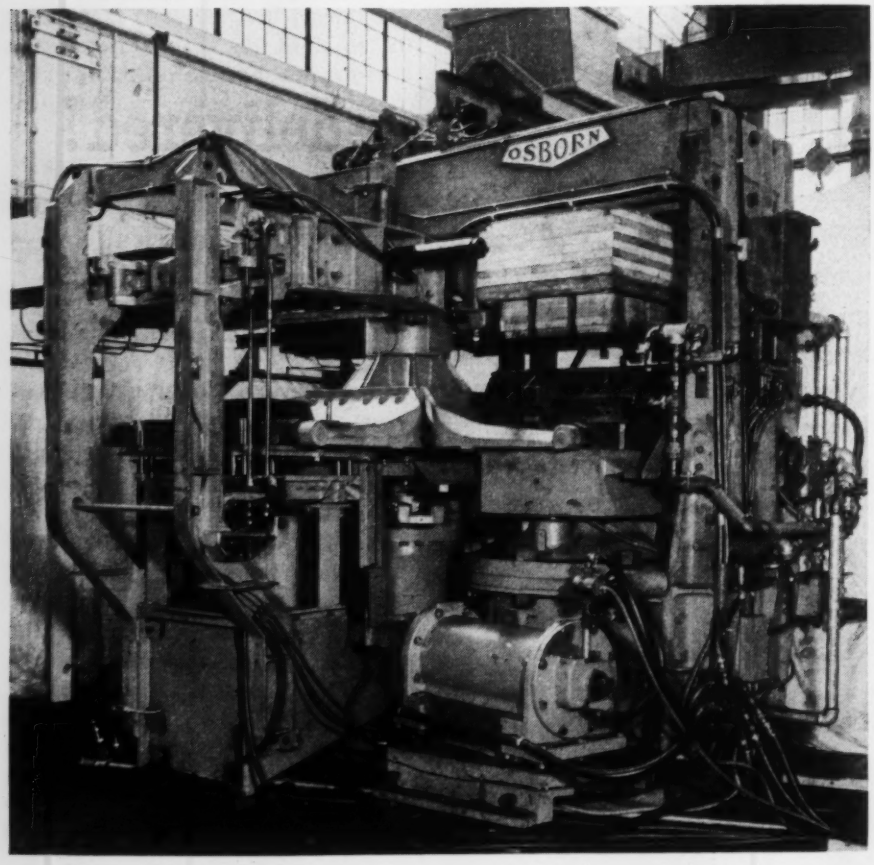
Automatic Molding Machine Makes Cylinder Block Molds

A rotary automatic molding machine capable of producing cylinder block half molds at the rate of 240 per hour is being placed in operation in a leading automotive foundry. Developed by the Osborne Mfg. Co., the machine produces molds of uniform quality which in turn produce uniform castings to the closest possible dimensional tolerances for processing on automatic machines.

Major operations required to make a mold are automatically performed at four stations. A half pattern which forms the mold contours is mounted on a platen at each of the four stations. The platens float in the turntable and can be raised at each station to permit the various operations to be performed. Patterns are cleaned at station No. 1. At station No. 2, the flask in which the mold is to be rammed is automatically transferred on rollers into position beneath the sand supply hopper and directly over the platen. The platen carrying the pattern is then raised by means of pneumatic pistons until the flask is in position on the pattern. The gate on the sand supply hopper is then opened until the flask is filled with sand. Next, the platen carrying the pattern, flask and sand is returned to position ready for indexing to the next stations.

While the above operation is taking place at station No. 2, a flask which has previously been loaded as above is given a predetermined number of jolts and then squeezed at station No. 3 to give the molding sand proper hardness and uniformity. Both jolt and squeeze operations are performed by pneumatic pistons. While a flask is being loaded and filled at station No. 2 and another is being jolted and squeezed at station No. 3, a third flask containing a rammed mold is being drawn from the pattern at station No. 4. The elevating mechanism for accomplishing the draw operation is similar to that used at loading station No. 2. At the finish of the draw operation, the completed mold rests on rollers and is discharged from the machine by means of a pneumatic piston.

This 80,000 pound molding machine will automatically produce 240 cylinder-block half-molds per hour, using 120,000 pounds of sand in the process



Prizes Awarded For Welded Designs

Awards totaling $5000 were presented to 51 undergraduate engineers at 21 different engineering schools for their papers describing machines or structures of arc-welded design entered in the Sixth Annual Engineering Undergraduate Award and Scholarship Program sponsored by the James F. Lincoln Arc Welding Foundation. Scholarship funds totaling $1250 were granted to the colleges attended by the three grand award winners.

Purpose of the awards, according to Dr. E. E. Dreese, chairman of the Foundation's board of trustees, is to encourage engineering students to study methods for improving and reducing costs of machines and structures by applying arc-welded design. All engineering undergraduates are eligible to participate in this annual competition.

Top award for a machine design was made to William J. Chancellor, a student at the University of Wisconsin, for his paper titled "Design and Construction of a Chain Mower." Some other prize winning papers are: "Welded Design Centrifugal Pump," "Design of a Portable Saw" and "Design of a Speed Reducer." Grand awards were also made for a welded bridge design and a design for all-welded materials-handling containers.

In visualizing AUTOMATIC ELECTRONIC CONTROLS for your equipment, think of them LIKE THIS

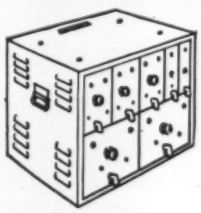
Are your prospects afraid of the "Little Black Box?"

Your wonderful new Electronic Controls may mean the death of a sale — unless the cautious buyer sees that his own personnel can locate and correct Control troubles on the spot.

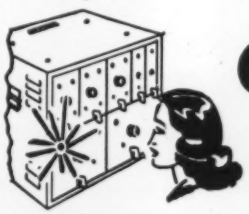
Any electronic equipment can now be subdivided into simple plug-in units that for the first time assure your users RELIABILITY IN SERVICE

(The User's own personnel can locate and correct most troubles on the spot)

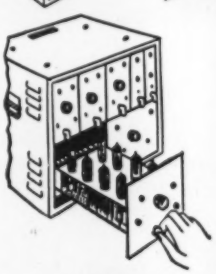
Here are the bold new Standards:



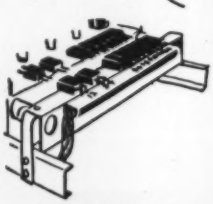
1 Circuitry subdivided, function by function into plug-in units.



2 Tiny telltales spot trouble instantly.



3 Plug in replacement spares in 30 seconds.



4 All leads brought to single accessible point of check — all numbered, color-coded — so layman can make first-level tests.

REQUEST FREE HANDBOOK

Describing complete system of Plug-in Unit Construction and Components. 226 pages and many Planning Sheets.

Here's how to get them: IT'S AS SIMPLE AS THIS –

1. ***Unitize your circuitry in compact vertical planes using Alden Terminal Card Mounting System.***

PREPUNCHED TERMINAL MTG. CARD
MINIATURE TERMINALS
JUMPER STRIP Eliminates wiring for common circuits
CARD-MTG. SOCKETS
YOUR COMPLETED CIRCUITS FOR PLUG-IN PACKAGE OR CHASSIS

You can use Alden Terminal Mounting Card with Alden Miniature Terminals, Jumper Strip and Sockets staked to accommodate any circuitry — making complete units ready for housing. Components snap into unique Alden Terminals, are held ready for soldering.

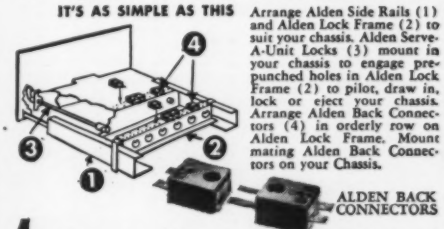
2. **To mount this vertical circuitry, ALDEN PLUG-IN PACKAGES AND BASIC CHASSIS give tremendous variety with standard components**

ALDEN PLUG-IN PACKAGE
4 SIZES: 7, 9, 11, & 20-PIN
ALDEN BASIC CHASSIS 2", 4", 8" & 17" widths
Plugged into Standard Racks
Plugged into Alden Uni-Racks
Plugged into Portable Cases

Standard Alden components provide tremendous variety to build almost any circuitry as plug-ins. With spares, your circuits are units replaceable in 30 seconds.

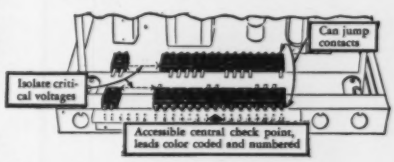
3. **Give chassis easily traceable interconnects and 30-second replacement with ALDEN SERVE-A-UNIT KIT**

IT'S AS SIMPLE AS THIS



Arrange Alden Side Rails (1) and Alden Lock Frame (2) to suit your chassis. Alden Serve-A-Unit Locks (3) mount in your chassis to engage pre-punched holes in Alden Lock Frame (2) to pilot, draw in, lock or eject your chassis. Arrange Alden Back Connectors (4) in orderly row on Alden Lock Frame. Mount mating Alden Back Connectors on your Chassis.

GIVING YOU 1) Chassis that plugs in, locks and ejects with half turn of the wrist. 2) leads so beautifully organized, accessible and identified that non-technical personnel can service.

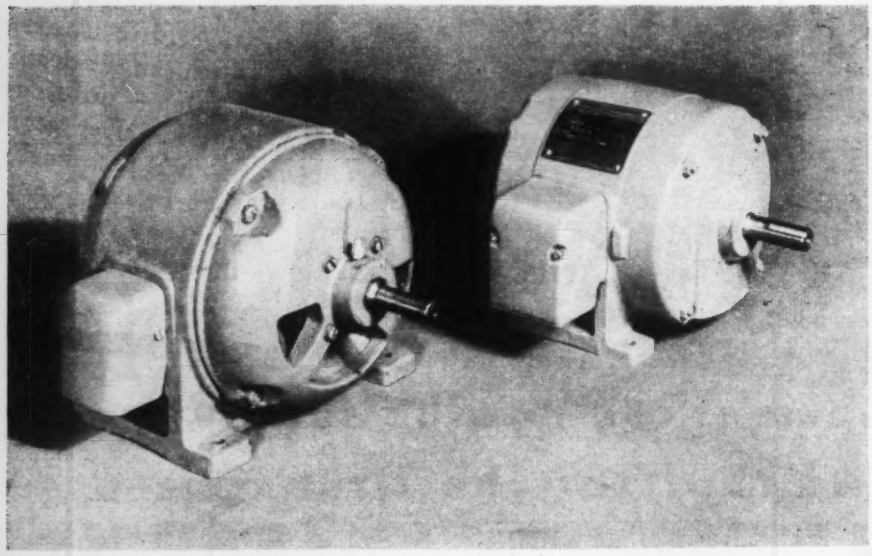


4. ***Assign to each unit ALDEN SENSING ELEMENTS — to spot trouble instantly:***

Compact front panel easily mounts 6 tiny Alden Sensing Elements — specifically designed to lick the problem of small space.

By thinking of your Electronic Controls in terms of ultimate plug-in units — you lick the problem of RELIABILITY IN SERVICE for your Customer . . . and you wash out problems of Design, Manufacture and Procurement for all concerned.

NA-ALD **ALDEN PRODUCTS CO.** 149 N. Main St., Brockton 64, Mass.



Old, left, and new, right, one-horsepower motors demonstrate reduced size of new GE TriClad "55" motors. Weight is also reduced by as much as 40 per cent in some models

New Motor Line To Latest NEMA Standards

A new line of polyphase ac motors built to latest standard NEMA frame dimensions has been announced by the General Electric Co.'s Small Integral and Medium Induction Motor Departments. Called TriClad "55" the new motors are smaller and lighter than previous motors of equal power. Average size reduction is 50 per cent by volume. Weight reduction averages 22 per cent for the line. Despite size and weight reduction full-load speed rating and efficiency are higher.

A new insulation system, bearing assembly and ventilation plan have been incorporated into the motor to provide better protection and quieter operation. A new polyester film, eight times as strong as previously used materials, is used to insulate the points of hardest motor wear. Tightly sealed bearings lubricated by new synthesized grease are said to last five times longer than other systems with ordinary grease.

Careful acoustical design of bearing housings, stator laminations and the ventilating system have resulted in a quieter motor with a more pleasing tone. A ten-horsepower motor is said to produce no more noise than previous two-horsepower models.

After the first of the year, the new motors will be available in NEMA 182 and 184 frame sizes (1, 1½ and 2 hp at 1800 rpm) in horizontal drip-proof and totally-enclosed, fan-cooled models and a complete line of gear motors. Larger frame sizes will follow at regular intervals. Other types to be produced in 1954 include vertical, single-phase, wound-rotor, explosion-proof, multispeed, face and flange-mounted models.

New Phosphate Coatings

A complete line of products in the chemical specialties field for phosphatizing metals for corrosion resistance and paint bonding has been announced by the Pennsylvania Salt Mfg. Co.

The new "Fosbond" line includes a complete range of phosphating compounds for application of various types of iron phosphate, zinc phosphate or manganese phosphate coatings. A complete new line of compounds for surface preparation prior to phosphating has also been developed. These cleaning and surface preparation compounds employ new activators which improve control of the ultimate coating desired.

In one series of these products cleaning and phosphating actions are combined, eliminating one step in the cycle. Other cycles have been arranged to provide coatings of minimum weight, yet uniform and very fine grained. Such coatings give the metal corrosion resistance and paint-bonding action and make possible very smooth finished painted surfaces.

Photocopy-In-Industry Contest

For the best reports on how photocopying and new photocopy techniques are being used effectively in business and industry, Peerless Photo Products Inc. is sponsoring a "Photocopy-Industry" contest.

Each month three awards will be given to the three best entries received by the tenth of October, November and December. The contest is planned to draw attention to the many new applications for photocopying—by both the "transfer process" introduced recently and the older "darkroom" techniques. Although originality of the application reported will be important, the significance of the result achieved by photocopying will be the primary basis for determining winners.

No special entry form is required—only a letter of explanation is needed—and a contestant may enter as many letters as he wishes. Winning reports will be published at the close of the contest as a portfolio of modern photocopy practice. Judges for the entries are the executive board of *Industrial Photography* magazine.

A $30 million seamless tube mill —the first west of the Mississippi —was opened recently at Pueblo, Colo. Full production of the mill, owned by Colorado Fuel and Iron Corp., will be 150,000 net tons of seamless pipe per year. The new industrial structure covers more than 10 acres under one roof. Construction began in February 1952 —the 10,000 ton steel framework taking five months to build. The mill consists of five long rectangular one story buildings joined side by side.

*Snap-tite QUICK CONNECT-DISCONNECT COUPLERS

CUT Carrier CORPORATION COSTS BY 84%

Carrier engineers asked us to devise a quick coupler which would quick-test evaporator and condenser coils for leakage—as the coils went along the production line. This process had been a bottleneck. It took many minutes to test, because a soft solder connection had to be made, the unit immersed in water, and the connection broken as the tests were completed. This was a very costly operation for Carrier.

Now, the four unit Snap-Tite coupler (shown on the right) is inserted in the two sets of tubes, immersed in water, tested for leakage in seconds. The labor cost in this operation was reduced by 84%. Carrier now uses these couplers in multiple and single units to test coils on several room air conditioner models.

This unique application is a good example of the cooperation that you, as a design engineer, will receive from Snap-Tite design engineers in solving your particular process or product coupler problem.

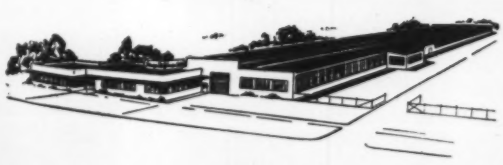
The Snap-Tite quick connect-disconnect coupler in testing position for Carrier tube test.

A close-up of the Snap-Tite couplers especially mounted to test Carrier tubes on their production line.

Snap-Tite will especially design and manufacture, in any quantity, quick connect-disconnect couplers to work smoothly and efficiently in or with your process or product.

Snap-Tite couplers are designed to work with air, water, petroleum, gas, steam and most chemicals. Size is not a problem; we make couplers in sizes from 1/8" to 8" and up—in steel, brass, stainless, aluminum, or other alloys.

Send us your coupling problem, and we'll work with you to a satisfactory solution. Send your prints—or your ideas to our Mr. Armand Probeck, Vice President.



*Snap-tite INC.

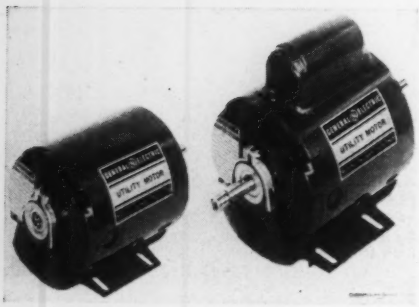
201 MALCOLM AVE., UNION CITY, PA.

NEW PARTS AND MATERIALS

For additional information on these new developments, see Page 207

Fractional-HP Motors

These utility fractional-horsepower motors are smaller and up to 40 per cent lighter than previous models of comparable ratings. The split-phase type is rated at 1725 rpm, ¼-hp single shaft extension, ⅓-hp single and double shaft extension, and ½-hp double shaft extension. The capacitor start models are rated at 1725 rpm, ⅓, ½ and ¾-hp single shaft extension; 1725 rpm, ½-hp double shaft extension and 3450 rpm, ½ and 1 hp double shaft extension.



All are single phase, 60-cycle, rated at 50 C continuous rise, are finished in blue-gray and can be mounted in any position. Made by **General Electric Co.**, Schenectady 5, N. Y.

For more data circle MD-66, Page 207

Air Cylinders

Featuring a built-in operating valve, this line of double-acting cylinders requires only one pipe connection and increases efficiency by reducing line friction. Valves can be furnished with dual speed con-

trols and are of the universal type so that they can be operated by poppets, direct or remote, or converted to double or single solenoid operation. Units are available in cylinder diameters ranging from 1½ through 6 in. A full line of two-way poppet valves will be offered in addition to standard electrical conversion units. Made by **Carter Controls Inc.**, 2914 Bernice Rd., Lansing, Ill.

For more data circle MD-67, Page 207

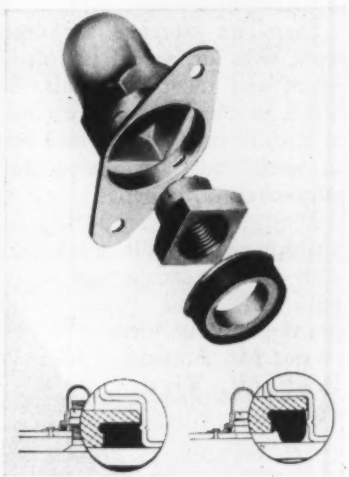
Insulating Laminate

Utilizing glass mat reinforcement, Micarta grade No. 20608 offers good electrical insulating qualities, excellent moisture resistance, toughness and high impact strength. It is available in 1/16 to ¾-in. thicknesses in 28 by 37-in. panels. In a ⅛-in. thick panel moisture absorption is 0.35 per cent, and dielectric strength is 350 v per mil. Applications include circuit breakers, coil washers and rotor wedges. Made by **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

For more data circle MD-68, Page 207

Self Sealing Nut

Bolted attachments are sealed without the use of sealing compounds by this floating dome nut, and the seal is not affected by flexure of structural components. The seal is in retracted position in the dome and therefore need not be compressed during attachment of the nut. Installation of bolt forces bearing surface of seal washer to contact the structure, providing single point sealing. Nut provides 0.025-in. float in all direc-



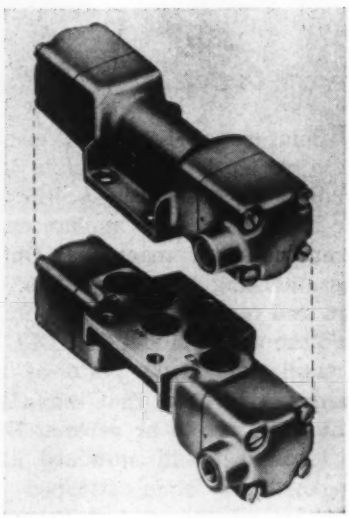
tions. It is available in 10-32 and ¼-28 NF-3 thread sizes. Seal material is resistant to atmospheric elements, salt water, oil, gasoline and most organic solvents. Applicable temperature range is −80 to 225 F continuous operation; applicable pressure range is ±50 psi, constant or fluctuating operation. Silicone seal material is available

with a temperature range to 500 F for use with hot air, ammonia and synthetic oil. Made by **Nutt-Shel Co. Inc.**, 811 Airway, Glendale 1, Calif.

For more data circle MD-69, Page 207

Manifold Mount Valves

Two, three and four-way types of ⅛, ¼, ⅜ or ½-in. NPT size valves are available in a manifold

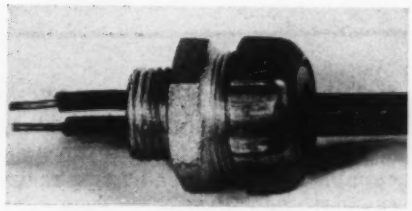


mount design, eliminating pipe or hose connections and saving space. Mounted on the manifold by means of bolts, the valve can be actuated by hand, foot, cam, pilot, solenoid or other actuating devices, all of which have spring return or spring center or return by the same or different actuating device. Complete servicing or disassembly, accomplished with a screwdriver, does not disturb pipe connections. Anti-extrusion arrangement of kinetic O-ring seals assures air tightness after 3 million cycles. Seal rings cannot be cut in the normal operating pressure range of 0 to 200 psig. Made by **Versa Products Co. Inc.**, 249 Scholes St., Brooklyn, N. Y.

For more data circle MD-70, Page 207

Electrical Connector

Providing a watertight connection for mineral insulated cable, this box fitting utilizes a Neoprene gasket as a moisture seal which

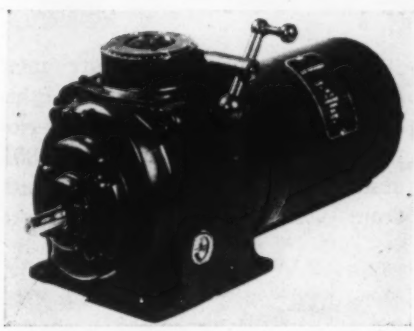


permits standardization on three connector sizes to fit mineral insulated cables from 0.309 to 0.730-in. diameter. The washer type grounding ring around the gasket insures a grounding path from the raceway to the fitting's metallic body. Watertightness is insured at the junction box or switch by the tapered hub threads. The screw-on pot shown in illustration contains a plastic filler acting as a further seal. Made by **Thomas & Betts Co. Inc.**, 36 Butler St., Elizabeth 1, N. J.

For more data circle MD-71, Page 207

Variable-Speed Drive

Improvements made in 1/6 to ¼-hp model 28 infinitely variable speed drive include 50 per cent more power in about the same size, use of two-piece housing with integral base and better control that provides equal changes in speed for equal changes in dial setting. Drive



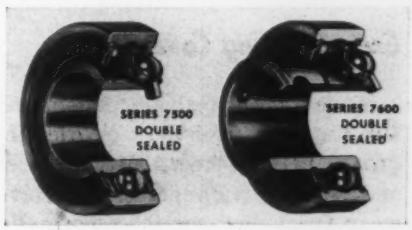
delivers all speeds from any desired maximum to zero, and speed can be changed with transmission running or stationary. Overload protection is incorporated.

Transmission is furnished as standard with micrometer control dial permitting easy adjustment to or between the 400 graduations. It can be had in mechanical reversing style in which all speeds from top to zero can be obtained forward and reverse without change in output rotation. Drive is available with wide variety of built-in reducer or step-up gearboxes, including single and double reduction helical spur reducers and right angle worm gear units with output shaft horizontal or vertical. Made by **Graham Transmissions Inc.**, Menomonee Falls, Wis.

For more data circle MD-72, Page 207

Precision Radial Bearings

These single row, solid race type precision radial bearings with ball retainer incorporate a labyrinth seal to retain lubricant and exclude foreign materials. Both series 7600, which has extended inner race with two locking set-screws and series



7500, without extension, can be provided with or without snap rings. Bearings are designed for medium loads and speeds up to 5000 rpm maximum. Normally double sealed, both series can be produced to order with seals on one side only, or without seals. Made by **Nice Ball Bearing Co.**, 2925 Hunting Park Ave., Philadelphia 40, Pa.

For more data circle MD-73, Page 207

Meter-Positioner

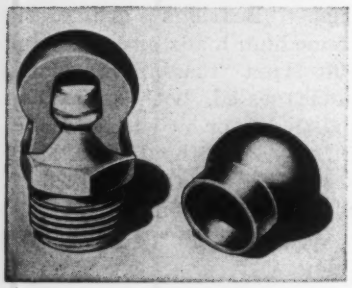
The output shaft mechanism of this magnetic fluid clutch meter-positioner will deflect up to 120 degrees with maximum rated output torque of 5.25 oz-in. at 4 ma. Responding linearly to signals from 10 to 500 microamperes, it is accurate to within 5 per cent and has flat frequency response up to five cycles per second. Two magnetic fluid clutches which weigh less than ½-lb each rotate in opposition with their output shafts linked. The output shaft mechanism responds to the resultant developed torques of the clutch input

coil signals. Life expectancy exceeds 3000 hr. Made by **Texas Instruments Inc.**, 6000 Lemmon Ave., Dallas 9, Tex.

For more data circle MD-74, Page 207

Grease-Fitting Cover

Made of oil-resisant Neoprene, Zur-Kap cover for Zerk or Alemite grease fittings keeps fitting clean and eliminates danger of excessive wear from dirt particles normally forced into the unprotected fittings with each application of grease.

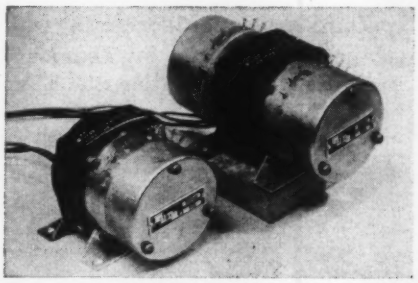


Covers snap on or off easily. Made by **Winner Mfg. Co.**, P. O. Box 945, Fort Wayne 1, Ind.

For more data circle MD-75, Page 207

Synchronous Choppers

Available in two models for switching at 60 or 30 cycles from a 60-cycle source, these precision motor driven commutator type switching devices commutate ac and dc signals in synchronism with 60-cycle supplies. Chopper life is 5000 to 10,000 hours in normal applications. As many as eight poles may be switched on one unit, with each pair of poles capable of independent phasing through 360 degrees. Commutation is by coin silver segments and slip rings working against fully pivoted carbon alloy brushes. Brush connections are bonded to glass-to-metal terminals for low noise. Contacts break before make, and slots are undercut so that brushes do not contact insulating material. Standard models lock-in on either half cycle of



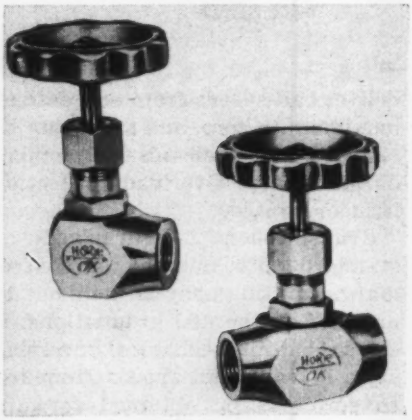
excitation phase—they are not polarized to the excitation. Made by **Instrument Development Laboratories Inc.**, 163 Highland Ave., Needham Heights, Mass.

For more data circle MD-76, Page 207

Needle Valves

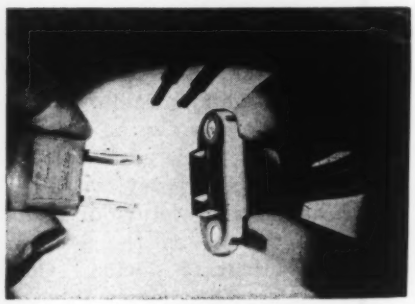
Available for direct instrument panel mounting in both straight-line and angle styles, 270 series valves are made of brass or 430F stainless steel bar stock in sizes from ⅛ to ½-in. NPT. Conventional packing or O-ring seals are offered, the latter being suitable for test panel high-pressure air or hydraulic service without packing adjustment. If helium leak tested, the O-ring style may also be used for high-vacuum service. Tight seating is assured by a self-aligning spindle. Repacking under pressure is possible. Made by **Hoke Inc.**, 191 South Dean St., Englewood, N. J.

For more data circle MD-77, Page 207



Electric Outlet

Miniature prewired ac convenience outlet is offered with leads tailored to customer specification for installation into appliances, instruments and machines. Outlets use mounting holes on 1⅛-in. centers and require less than 1 in. behind the panel. Model 402ACCL has a single mounting plate of cadmium plated steel that mounts by spot weld, rivets or screws. Built-in leads come in standard 12-in. length, free ends stripped and



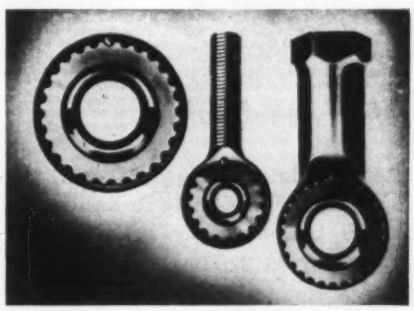
tinned, or special lengths to order. Solid molded phenolic body has isolated pockets for each contact. Made by **Alden Products Co.**, 117 North Main St., Brockton 64, Mass.

For more data circle MD-78, Page 207

Spherical Bearings

With bearing race inserts that adjust to any desired degree of relationship to the ball, Adjusta-Ball bearings may be positioned to correct misalignment and to compensate for wear. A spanner wrench inserted in notches on the outer

edge tightens or loosens the race; each notch adjustment is slightly less than 0.001-in. After adjustment the bearing race inserts are locked in position. The inserts are made of Mueller 600 bronze, and the ball is SAE 52-100 hardened and chrome plated steel. Line in-



cludes various sizes and types of spherical bearings and spherical rod-end bearings, all of which are prelubricated. Lubrication is supplied through the stem in rod end bearings and through lubrication holes in the spherical bearings. When specified, the bearings can be supplied with seals to hold the lubricant in the body of the bearings. Made by **Lincoln Park Industries Inc.**, 1719 Ferris Ave., Lincoln Park 25, Mich.

For more data circle MD-79, Page 207

Elapsed Time Meter

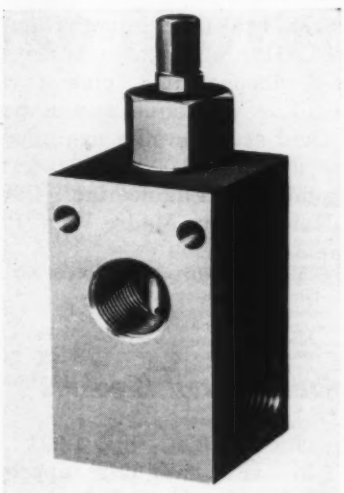
Special reset counter permits resetting to zero at any time. Model C5 has a range of 10,000 hr, counts in 1/10-hr and can be supplied for 115 or 220 v operation at 60, 50 or 25 cycles; Model C5A, supplied for the same ratings has a range

of 100,000 hr and counts hour units. Heavy duty, self lubricated motors are connected through gears to five digit counters that record the number of hours or minutes elapsed. Steel housings measure 2⅞ in. in diameter, 3¼ in. long; mounting flanges measure 3¼ square. Timers are also available as open type meters. Made by **Industrial Timer Corp.**, 117 Edison Place, Newark 2, N. J.

For more data circle MD-80, Page 207

Relief Valves

With relief pressures adjustable between 50 and 300 psi, line of ¾ in. relief valves are of the pilot type and have constant pressure characteristics. This construction also gives large capacity in small space, the overall size of the units

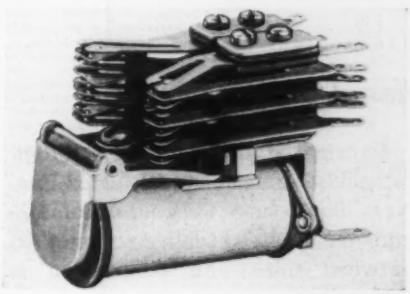


being 2 by 2 by 5¼ in. Valves are for use with oil or gasoline. Made by **Fluid Controls, Inc.**, 1284 N. Center St., Mentor, O.

For more data circle MD-81, Page 207

Relays

Included in line of relays is the series 100 dc computer relay, bearings of which have essentially zero friction. Life span is said to be 10 million cycles. Series 300 dc miniature relays weigh under 2 oz and incorporate an antivibration feature. Series 400 ac or dc coaxial relays withstand 10*g* vibration at 10-55 cycles per second under operation tests. Series 500 dc communication relays can perform mechanical work in addition to operating contacts, making them applicable where automatic punching is

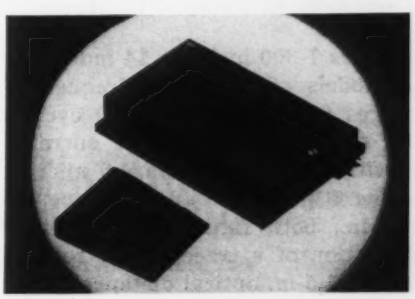


required for control system applications. Contact ratings range from 3 to 10 amp. Relays weigh from 2 to 10 oz. Made by **Joseph Pollak Corp.**, 81 Freeport St., Boston 22, Mass.

For more data circle MD-82, Page 207

Subminiature Amplifier

Model 2607, incorporating subminiaturized components and etched circuit wiring, provides an input impedance of over 150 megohms for piezoelectric, capacitive and other types of measuring instruments. Small tubes and shock resistant construction provide a high gain stability of 3 per cent under varying supply and ambient conditions, making the unit suitable for telemetering or electronic recording systems requiring a full 5 volts. Designed for use with Endevco accelerometers for installation in mis-



siles and aircraft or on ground tests with severe temperature and vibration conditions and for telemetering vibration and shock data from 5 cycles per second to 20 kilocycles, the device also finds application in fields such as dc strain gage amplification. Made by **Endevco Corp.**, 689 South Fair Oaks Ave., Pasadena 2, Calif.

For more data circle MD-83, Page 207

Hose Clamps

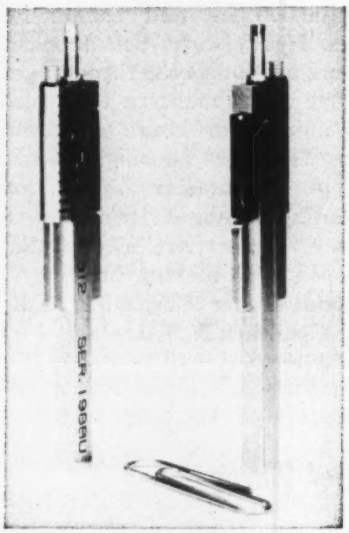
Fabricated in one piece from nonfatiguing spring steel, Hoz-Fas-Ners clamp hose with an automatic and constant tightening action. Seal between hose and connection is maintained despite such factors as hose ageing, shrinkage or expansion. Clamps are easy to apply and do not require manual adjustment or retightening. They can be reused. Rounded surface prevents

cutting of hose; finish is rust-resistant. Made by **Eaton Mfg. Co.**, Reliance Div., Charles St., Massillon, O.

For more data circle MD-84, Page 207

Recording Galvanometers

Series 7-300 includes 14 individual models offering flat frequency ranges from 0.11 to 0-3000 cycles per second. Undamped dc current sensitivities range from 4.6 microamperes per in. to 40 milliamperes per in., both figures representing deflection of a trace on the record at an 11.5-in. optical distance. One-

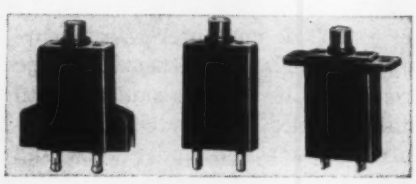


piece construction and a fixed window behind the lens turret provide a positive seal against dust, moisture and other foreign matter. Lens mounts can be rotated, permitting use in oscillographs of different optical bases. All lens and window surfaces are magnesium fluoride coated. Use of highly stable degassed silicone fluid, plus a vacuum-filling technique and a positive fluid seal, permits use at altitudes up to 100,000 ft. Made by **Consolidated Engineering Corp.**, 300 North Sierra Madre Villa, Pasadena 8, Calif.

For more data circle MD-85, Page 207

Miniature Circuit Breakers

Measuring 2.44 by 1.221 by 0.571-in. and weighing approximately 1.5 oz, the E-T-A thermal single pole miniature overload circuit breaker provides protection for ac motors, television sets, instruments and electrical and electronic equipment. Features include an amply rated bimetal thermal device, steatite base, bakelite case, simple release mechanism, rapid restoration of circuit after operation, long life. Maximum



voltage ratings are 250 v ac and 24 v dc. Current ratings range from 50 ma to 25 amp. The breaker can be used for 230 v dc supply if expected short circuit current does not exceed 6 amp. Available from **E-T-A Products Co.**, 915 West Oakdale Ave., Chicago 14, Ill.

For more data circle MD-86, Page 207

Safety Relief Valve

Available in sizes from 1½ through 6 in., Uni-Line series 41-W-200 boiler safety relief valves are reported to have a high capacity for unit size. Other features include self-aligning disk which, together with the disk holder, are of forged copper alloy; and a floating adjustable guide

which assists in opening and closing actions. Made by **J. E. Lonergan Co.**, Second and Race Sts., Philadelphia 6, Pa.

For more data circle MD-87, Page 207

Lubrication System

Minute quantities of lubricant are delivered to as many as 36 individual points, regardless of the differences in pressures required by this Lo-Flo lubricator. This flexible unit, offered in 18 or 36-point feed models with or without group regulation, is adjustable for flow

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rates from 2.3 cu in. per hour to less than 1 cu in. per 700 hr. Lubricants ranging from light oils to

light grease can be handled at 60 F. Outlets can be manifolded internally to increase flow to selected bearings, and unit can be used with separate or integral reservoir. Available drives are rotary shaft, built-in ratchet, solenoid and pressure pulsation of liquids or gases. On large systems, a number of remotely located units can be driven and supplied from a convenient central station. Working pressure is 500 psi. Made by **Nathan Mfg. Corp.**, 416 East 106th St., New York 29, N. Y.

For more data circle MD-88, Page 207

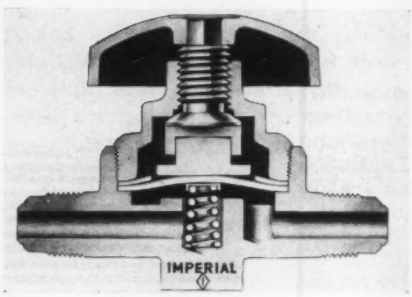
Glass-Cloth Laminate

Epoglas, a laminate of epoxy-resin and glass cloth, is available copper clad on one or both sides for etching, or unclad for use in terminal boards or as a base for plated and printed circuits. Sheets measure 24 by 36 in. in thicknesses from 0.003 through 0.500-in. The epoxy resin has a high bond strength to copper when laminated under heat and pressure, and since adhesives are not required, electrical and mechanical properties are unimpaired in the completed circuit. The laminate is suited to dip soldering, can be fabricated, and will not delaminate. Water absorption is 0.016 per cent; service temperature is 175 C; and dielectric constant, surface resistivity and arc resistance are high. Made by **Plastilight Inc.**, 481 Canal St., Stamford, Conn.

For more data circle MD-89, Page 207

Packless Shutoff Valve

Especially adapted for vacuum applications, instrumentation, processing, pneumatic service, and similar industrial service, this Red Head packless shutoff valve has a solid Teflon diaphragm. Valve gives positive shutoff with easy fingertip operation and will withstand unlimited openings and closings. It handles pressures up to 300 psi and holds full vacuum. Temperature range is −100 to 450 F. It is available with 45-de-

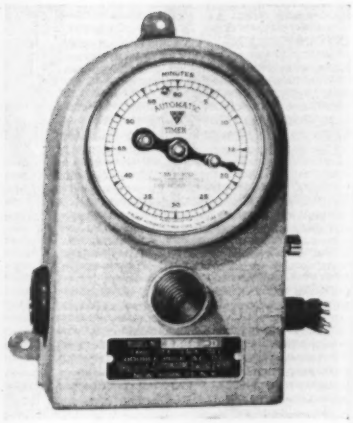


gree flare or solder connections for tubing in sizes from ¼ to ⅞-in., and in ⅜ and ½-in. female pipe connections. Styles include both tube-to-tube straight-through valve and angle valve with tube-to-pipe thread. Made by **Imperial Brass Mfg. Co.**, 1200 West Harrison St., Chicago 7, Ill.

For more data circle MD-90, Page 207

Interval Timer

Adaptable to every signalling requirement, this interval timer provides on-the-spot or remote audible and visual signals indicating completion of set timing cycle. Two models are available, No. 8033D with a 30-minute full range, and

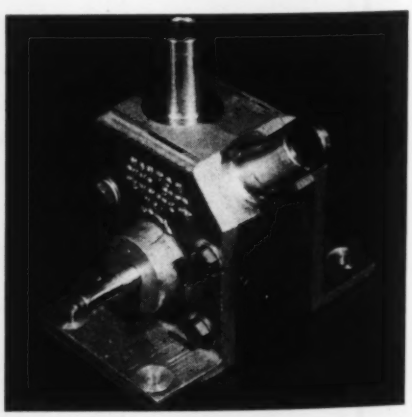


No. 8066D with a 60-minute full range. Timer is hand set to any requirement. Of the two sets of leads brought into the housing, one is for single-pole connection to close operating circuit of the machine being controlled, the other feeds pilot light and signal receptacle. A pushbutton switch is used to reset the mechanism. Operating loads of up to 12 amp, 110 v ac or dc can be controlled. Made by **Walser Automatic Timer Corp.**, 420 Lexington Ave., New York 17, N. Y.

For more data circle MD-91, Page 207

Stainless Steel Pump

Available in capacity ranges from 1/3 to 20 gpm and for discharge pressures ranging from 0-60 psi with suction lifts up to 26 in. of mercury, self-priming stainless steel series S pump is useful for handling a wide variety of foods and chemicals. The only parts contacting the fluid being pumped are the stainless steel

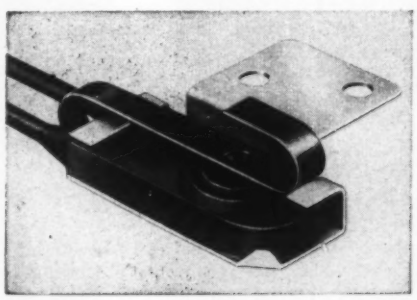


body block and the corrosion resistant liner, which is available in a wide range of moldings including gum and natural rubber, Buna N, Hycar, Neoprene, vinyl, silicone and Compar so that the best material can be suited to the particular job. Made by **Vanton Pump Corp.**, Empire State Bldg., New York 1, N. Y.

For more data circle MD-92, Page 207

Waterproof Switch

A Neoprene covering makes this switch impervious to acids, water, grit, dirt, dust and oil. Two and three wire types are available, and toggle models can be supplied. All models feature "sine curve" contact design. Waterproof covering is available in both silicone and synthetic rubbers, depending upon specific application. Uses include commercial vehicles, refrigeration

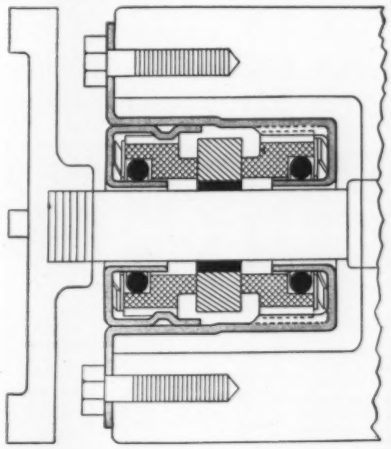


equipment, marine installations, packaging machines, bottling equipment, vending machines and farm machinery. Made by **Control Products Inc.**, Sussex St., Harrison, N. J.

For more data circle MD-93, Page 207

Mechanical Shaft Seal

Double-face cartridge designed to meet requirements of high pressures, temperatures and revolutions per minute is positive sealing, requires little space, and adapts readily to various applications. All parts are contained in a compact housing cup. Installation is accomplished by pushing the seal onto the shaft and tightening the mounting screws. Stator rings insure close hydraulic balance even when pressure is applied from either side of the seal. It is made of material

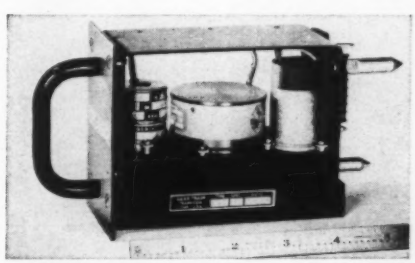


compounded to seal virtually any liquid or gas. Rotor can be made of various materials. Pressed-in or flanged mountings are avialable. Made by **Cartriseal Corp.**, 3515 West Touhy Ave., Lincolnwood 45, Ill.

For more data circle MD-94, Page 207

Servo Subassemblies

Plug-in unit, illustrated, contains a motor-driven potentiometer and a synchro. Rotation of the potentiometer is limited by internal stops to 300 degrees. Gear ratio between the synchro and the potentiometer is 2.5 to 1, and the



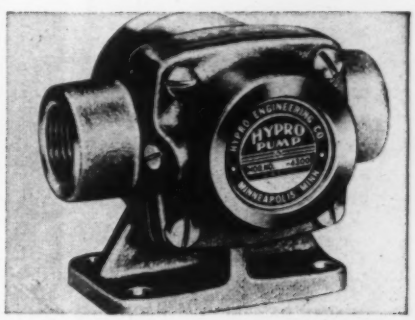
gears are protected by a slip clutch.

Another subassembly consists of a motor-driven induction generator driving a linear synchro, linked through a 6000 to 1 gear train. A similar unit contains a motor-driven induction generator and drives two linear synchros and an output shaft. The subassemblies are available in numerous combinations. Made by **Transicoil Corp.**, 107 Grand St., New York 13, N. Y.

For more data circle MD-95, Page 207

Industrial Pump

With scoop rotor and rubber roller type vanes, model 4300 industrial pump has sealed, permanently lubricated ball bearings which permit use for continuous duty service. Pressed fit of stainless steel shaft into inner ball bearing race to restrict lateral movement of the rotor minimizes end thrust wear within pump. Impeller is self-lubricated by water and delivers about 7 gpm at 50 psi and 1750 rpm. Pressure range is from 0 to 75 psi. Unit is fur-



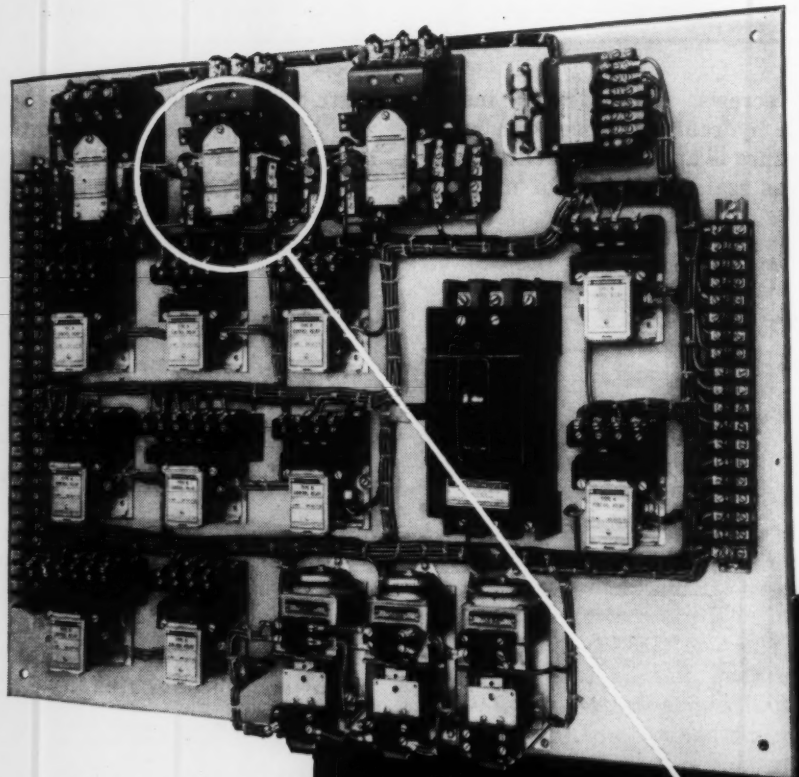
nished with ¾-in. ports, and recommended speeds are up to 1800 rpm. Made by **Hypro Engineering Inc.**, 404 North Washington Ave., Minneapolis 1, Minn.

For more data circle MD-96, Page 207

Tubing Plugs

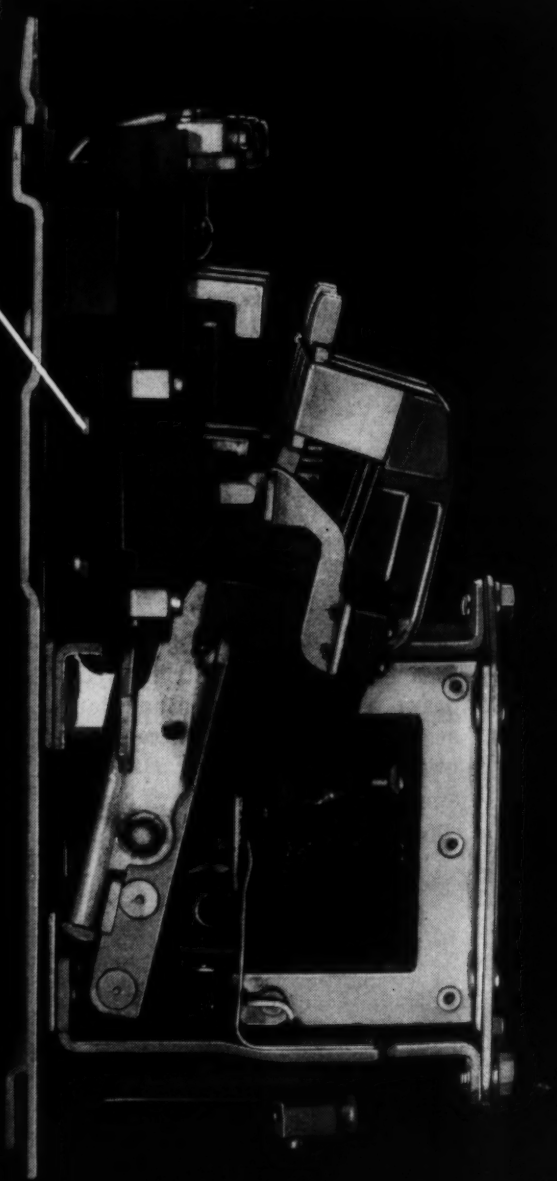
Threaded plugs for aircraft and hydraulic tube fittings are available in 12 standard sizes from 5/16-in.-24 thread to 2½ in.-12 thread. Made from tough, flexible polyethylene, they are impervious to all common chemical reagents, acids and solvents and do not chip, break or shred under most severe conditions. Threaded at the top for ease of application, they seal beyond military require-

(*Continued on Page* 226)



Typical special control panel with all Westinghouse components.

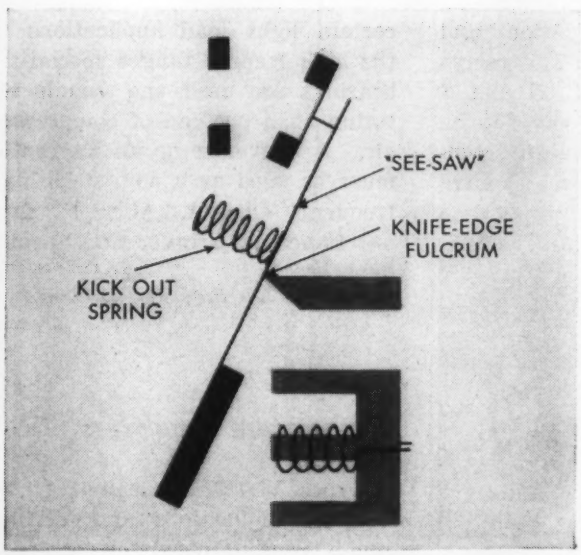
Compare the Westinghouse complete control line for any application



Westinghouse Life-Line Starter

Compare...

Simple knife-edge principle means longer life in Westinghouse *Life-Line* starters



Contact assembly is pulled against a stationary magnet—pivots on a frictionless knife-edge fulcrum. 13 years of field and laboratory testing proved the superiority of this design.

This attractive, Bonderized, general-purpose enclosure is one of many NEMA type enclosures for any industrial application. A complete line of open Life-Line Starters are available for use in machine cavities or panels.

Longer wear in the starters you buy means better performance of the machines you sell. That's why it pays to compare Life-Line Starters—for unfailing, trouble-free service over millions of operations.

Life-Line Starter has only one moving element—a "seesaw" balanced on a special knife-edge bearing. A positive kickout spring provides the contact-opening force.

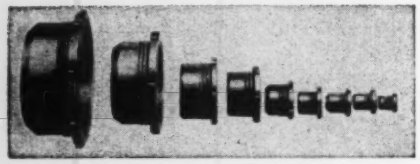
This exclusive Westinghouse design eliminates two undesirable features of conventional starters: sliding members and gravity action. Life-Line's moving element is friction free—cannot stick or jam—needs no lubricating—is self-aligning. And Life-Line Starters never operate falsely due to vibration, stress or accidental impact. You can count on dependable performance on any type of machine—under any operating condition.

Simplified design, longer life, greater dependability—these are fundamentals of the Westinghouse complete control line—starters, relays, timers, transformers, terminal blocks, oil-tight pushbutton stations. On your machines, in your panels, Westinghouse controls mean more profit and customer satisfaction.

For complete information and application assistance on Life-Line Starters and other Westinghouse control equipment, call your Westinghouse Representative, or write Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. J-30152

YOU CAN BE SURE...IF IT'S Westinghouse

(*Continued from Page* 223)



ments. Nonthreaded caps and plugs are available for ⅛ to 1½-in. diameters, with special sizes offered up to 3½ in. Made by Ca-Plugs Div., **Protective Closures Co. Inc.**, 2207 Elmwood Ave., Buffalo 22, N. Y.

For more data circle MD-97, Page 207

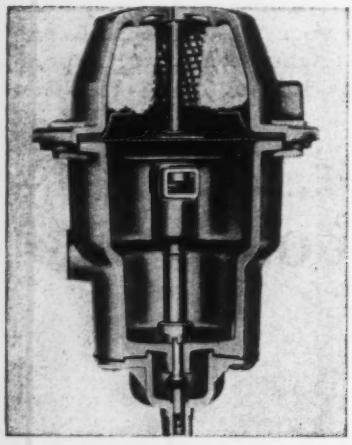
Rust Preventive

Siliconized Witch Oil lubricates and provides protection for work in process or for finished parts in storage. It has high resistance to oxidation, good moisture and water repellency and very good corrosion resistance. Made by **Mitchell-Bradford Chemical Co.**, 2446 Main St., Stratford, Conn.

For more data circle MD-98, Page 207

Moisture Separator

Automatically separating and discharging all nongaseous contaminants from air lines, model 1002-A separator is available for

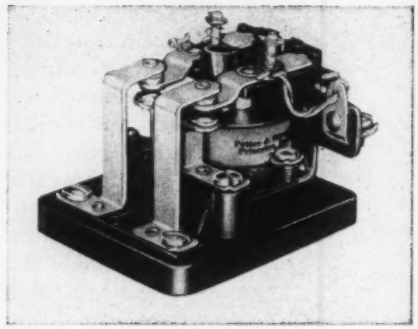


¼, ⅜ and ½-in. air lines. Separator stores air pressure to discharge accumulated water and sludge which collects from a main expansion chamber and an auxiliary filter. Use of the line served by a unit triggers the discharge of any accumulation. Device has only one moving part actuated by a diaphragm. Made by **Wilkerson Corp.**, 3377 South Platte River Dr., Englewood, Colo.

For more data circle MD-99, Page 207

Heavy-Duty Relays

Entire PR series of heavy-duty power relays is now equipped with one-piece molded plastic bases, providing better insulation and more rugged service. The relays designated PR 1, 2, 3, 5 and 7 measure 2 9/16 by 2½ by 2⅜ in. high and fit 1⅞-in. mounting centers. PR models 4, 8 and 11 have

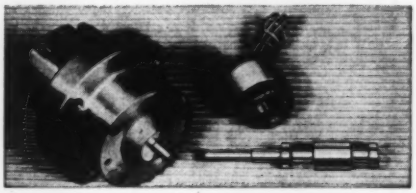


an insulating barrier molded to the base between stationary contacts, providing an increased over-the-surface leakage path. They fit 1⅞-in. mounting centers also and are 3⅜ by 2½ by 2⅜ in. high. Contact ratings: single break, 15 amp; double break, 20 amp, 115 v ac noninductive load. Coil voltages: 6, 12, 24, 115, 230 ac; 6, 12, 24, 110 dc. Made by **Potter & Brumfield**, Princeton, Ind.

For more data circle MD-100, Page 207

High Frequency Motors

Hi-frequency motors for experimental and production applications have speeds up to and beyond 100,000 rpm. Simple, compact units have rotor mounted directly on the spindle, it being the only moving part of the driving motor. Stator, carrying the motor windings, is cooled by a water jacket. Lubrication is by oil mist carried in a stream of air. Motor is totally enclosed. Normally, preloaded ball

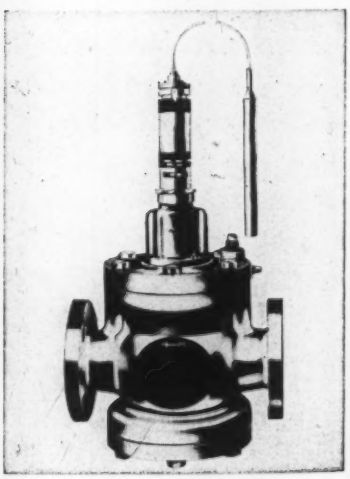


bearings are incorporated, but for certain light load applications in the higher speed ranges special air bearings are used, the spindle rotating on a cushion of compressed air. A converter or an alternator must be used as a source of high frequency current. Made by **Bryant Chucking Grinder Co.**, Springfield, Vt.

For more data circle MD-101, Page 207

Temperature Regulators

Types V1000 direct acting, for heating applications and VR1000 reverse acting regulator, for cooling, are compact, self contained pilot operated units, which incorporate the principle of liquid ex-



pansion employed in larger valves. A seated pilot valve positions the piston of the main valve, which

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Special Treatment Withstands Condensation of Moisture On Motor Windings at -38°

Industrial trucks built by Crescent Truck Company, Lebanon, Pennsylvania, for use in the plant of Polar Cold Storage Company, are specially engineered for the application. Trucks are built with an extremely short turning radius to permit ready maneuvering in the narrow aisles necessary to conserve space in a cold storage warehouse. Special treatment of the windings on the drive and pump motors is also necessary to withstand condensation of moisture with the trucks entering and leaving the 38 degree-below-zero refrigerated areas.

Crescent lift trucks used in this cold storage warehouse are powered by Star-Kimble traction motors with windings treated to prevent condensation of moisture.

Drive and pump motors for this severe service were engineered and built by Star-Kimble. Motors are of the ET type, designed for 30-volt storage battery operation, and use Class B insulation to provide high capacity and compactness.

The Class B insulation is treated with a varnish formulated to withstand condensation of moisture on the windings. The Star-Kimble motors on these Crescent trucks have been in service for periods as long as five years (9 hours a day), under severe loading conditions and extremes of temperature, with little or no maintenance.

Information on Type ET d-c traction and pump motors for industrial truck service is available from Star-Kimble Motor Division of Miehle Printing Press and Mfg. Co., 201 Bloomfield Avenue, Bloomfield, New Jersey.

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Stopping of a Star-Kimble Brakemotor is split-second in action, precisely timed by simple adjustments. Quiet, too — no lining screech. Low lining pressure, evenly distributed, assures long brake life. Brake is self-adjusting to compensate for lining wear — ruggedly built to withstand shock and vibration.

Braking force is spring applied, magnetically released. No linkages to cause lost motion or friction.

Starting of a Star-Kimble Brakemotor is smooth and free from drag. Small magnetic air gap assures quick brake release without high inrush current.

And Star-Kimble Brakemotors *maintain* this fast, smooth stop-start operation through millions of cycles with little or no maintenance attention. Brake and motor are *designed* together to *work* together as a single compact unit. One manufacturer, one responsibility — backed by years of experience. For details on construction, motor ratings and braking torques, write for Bulletin B-501-A.

Standard and special motors of all types, 1 to 600 hp; Marine motors ½ to 600 hp; generators and motor-generator sets, 1 to 500 kw.

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controls the throttling position of the main valve disk. Built-in self cleaning steam strainers protect vital parts of both the pilot and main valves, and complete internal porting is provided. The regulators control temperatures from 25 to 275 F through a 50 F range and are available in 2 to 4-in. pipe sizes. Maximum pressure limit is 125 psig. Made by **Farris Stacon Corp.**, 702 Commercial Ave., Palisades Park, N. J.

For more data circle MD-102, Page 207

Miniature Circuit Breaker

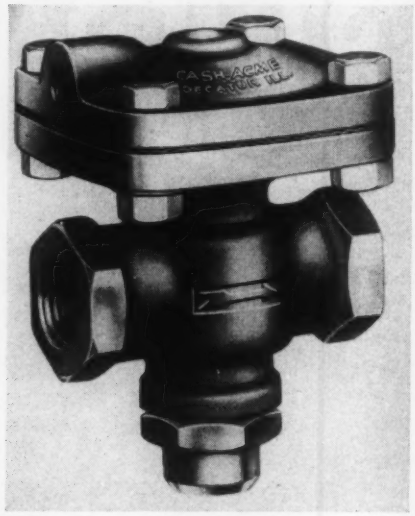
A thermally actuated circuit protective device rated at 10-amp provides improved circuit protection for small motors used in appliances, blower fans and similar applications. Service is restored after interruption by pressing in and releasing the Mini-Breaker's shockproof reset button. Resetting is not

possible, however, until the condition causing the overload has been eliminated. In addition to interrupting excessive overloads and short circuits, the device has a built-in time lag to handle temporary starting overloads and line surges. Made by **Mechanical Products Inc.**, 1824 River St., Jackson, Mich.

For more data circle MD-103, Page 207

Diaphragm Operated Valve

Type D-53 diaphragm operated control valve is suitable for applications where it is desirable to control pipe line flows of air, water, various chemicals and gases by independent pressure applied to the diaphragm. It is available in ½ or ¾-in. pipe sizes, for pressures up to 250 psi. Maximum diaphragm pressure is 300 psi. Normally-open

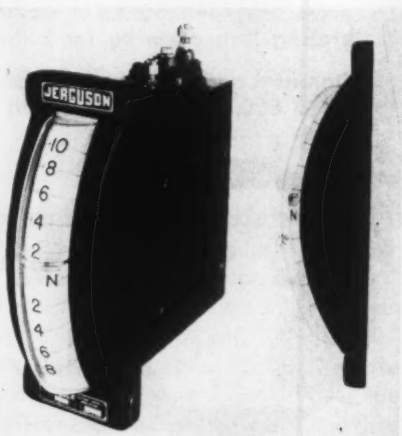


or normally-closed types are available. A typical use is for the control of water cooled compressors. Made by **A. W. Cash Valve Mfg. Corp.**, 666 East Wabash Ave., Decatur 60, Ill.

For more data circle MD-104, Page 207

Convex Scale Gage

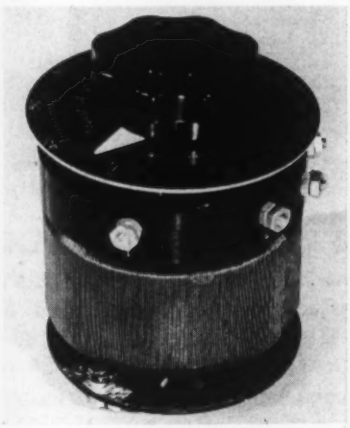
With 180-degree visibility, this gage can be read from any spot in the control room where the gage cover is visible. Liquid level readings may be taken instantly from the front or either side without distortion. Accurate to 0.5 per cent of scale reading, the compensated manometric gage meets the new interpretation of the boiler code for WSP of 900 psi or higher. Models are available for any pressure and range, and there are no stuffing boxes. Made by **Jerguson Gage & Valve Co.**, 80 Fellsway, Somerville 45, Mass.



For more data circle MD-105, Page 207

Auto-Transformer

Preadjusted brush assembly of the type 300BU Adjust-A-Volt auto-transformer maintains almost constant pressure from full-brush to no-brush. Electrical connection between brush and current take-off point of the brush assembly is direct. Unit is dimensionally small and compact and controls large power for its size. It is suitable for clockwise or counter-clockwise rotation and over-voltage (0 to 135 v) or line voltage (0 to 115 v) operation. Maximum load rating of

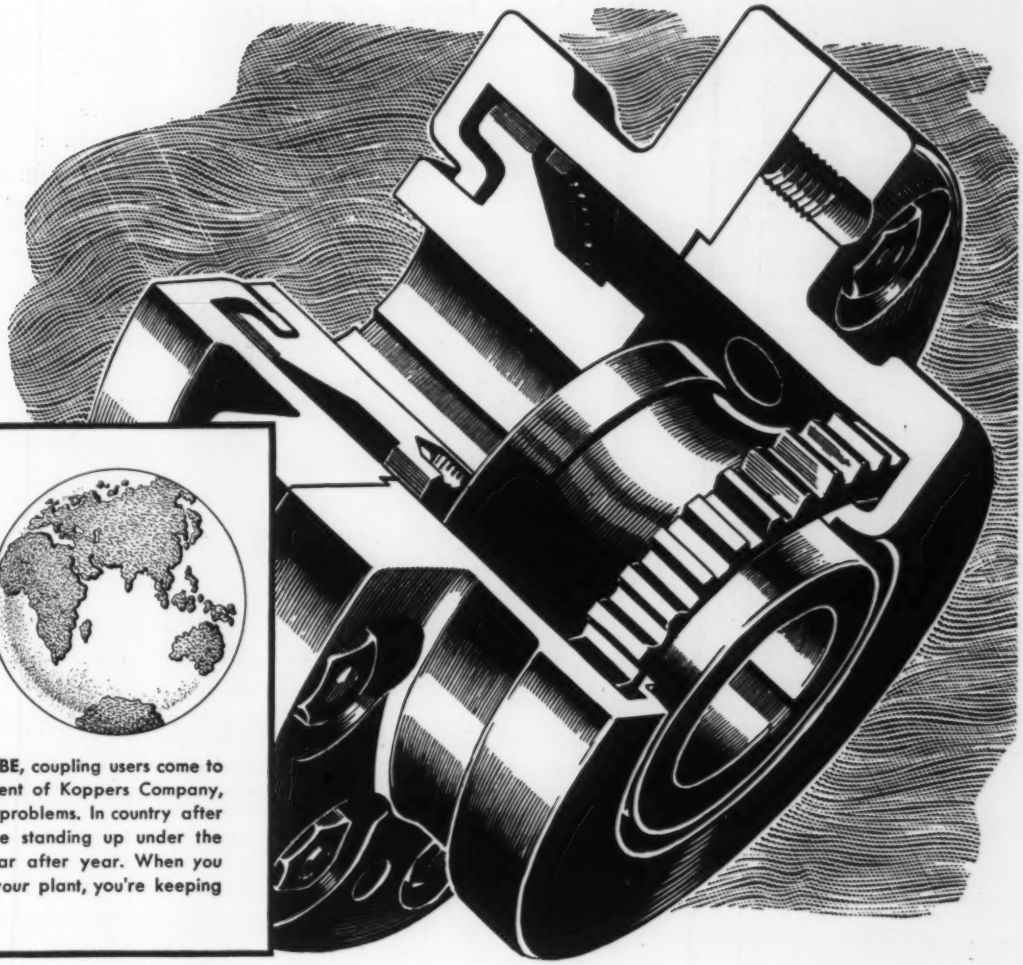


0.4-kva is available in single or ganged assemblies. Applications include power supplies, oven heat control, instruments and control of motor speeds. Made by **Standard Electrical Products Co.**, 2240 E. Third St., Dayton, O.

For more data circle MD-106, Page 207

Component Holders

Offering rigid mounting under conditions of heavy shock and vibration in limited space, holders provide a 180-degree contact sur-



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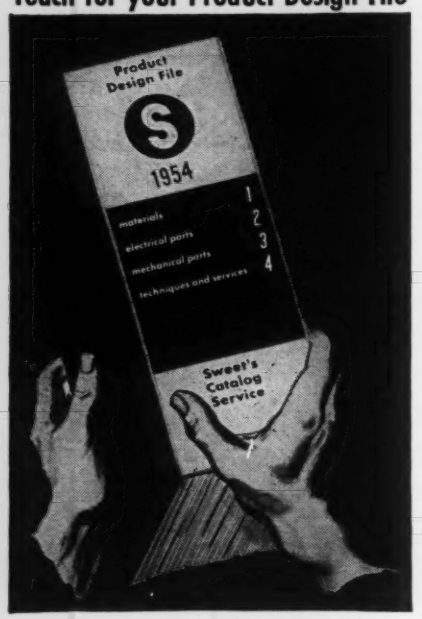

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Sweet's Catalog Service

Division of
F. W. Dodge Corporation
119 West 40th Street,
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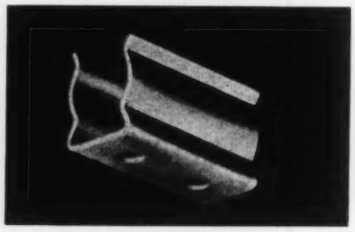
face the full length of the part. They are made of cadmium plated spring steel in sizes to accommo-

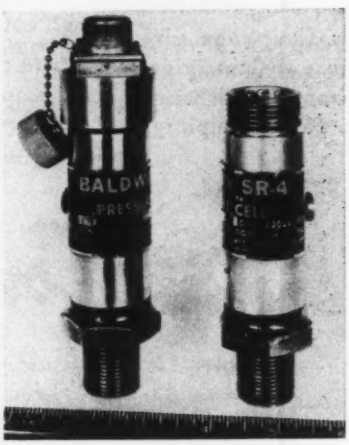


date 0.175 to 1-in. diameter components in lengths to 2 in., such as tubular capacitors, 1 and 2-watt resistors, miniature and subminiature tubes. Made by **Atlas E-E Corp.**, Bedford Airport, Bedford, Mass.

For more data circle MD-107, Page 207

Pressure Cells

Consisting of pressure-sensitive tube on the outside of which are bonded special SR-4 strain gages, high frequency pressure cells are available in standard capacities of 1000, 2000, 5000, 10,000 and 20,000 psi. Cells are usually connected to operate an oscilloscope for high frequency response, although pressure changes can be measured by means of electrical indicator or recorder of the potentiometer type.

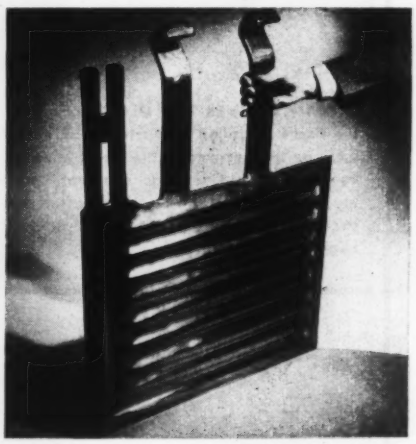


Upper frequency response is limited by cavity resonance of tank or piping connected to it. High accuracy can also be obtained in static pressure measurements in −60 to 150 F range. Cells measure 5½ by 2 in. and weigh 1 lb. Made by **Baldwin-Lima-Hamilton Corp.**, Philadelphia 42, Pa.

For more data circle MD-108, Page 207

Lead Plate Heater

Available in three sizes with 6.6, 9.9 and 13.2 sq ft of heat transfer surface, lead plate type heaters are designed for use with corrosives in chemical and processing work. Light, compact and strong,



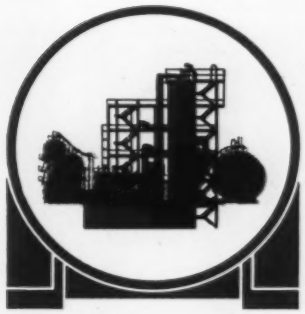
lead plate heaters use 10 psi steam or less. Lead has exceptional resistance to corrosion from sulphuric, phosphoric and chromic sulphurous acids, sulphates and the like. Made by **Knapp Mills Inc.**, 23-15 Borden Ave., Long Island City 1, N. Y.

For more data circle MD-109, Page 207

Solenoid Valve

Series V61 stainless steel cutoff valves feature snap-action closing and absolute, bubble-tight sealing. Standard models V61-200, rated at 250 psi with 0.136-in. orifice, and V61-300, rated at 300 psi with 0.125-in. orifice, are tapped for ¼-IPT pipe size and are available for 6 or 12-v dc operation. Size is 2¾ in. high by 2¼ in. in diameter; weight is 1½ lb. The valves shut off positively regardless of posi-

Fuel Pumping



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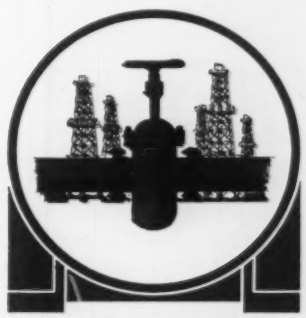
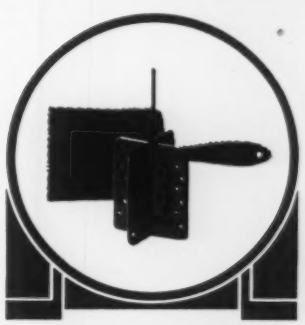


Pipe Line Pumping



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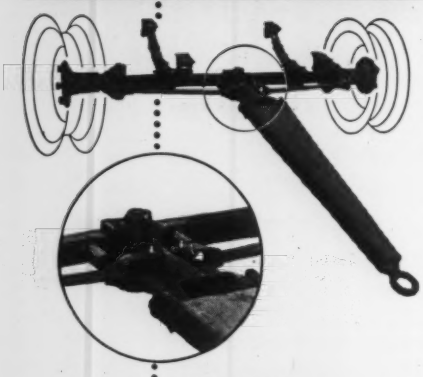

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STEERING

Only CARAVAN axles with automotive steering assure dependable roadability on both highway and rough ground. For positive trail at high speeds, these job-engineered assemblies feature controlled camber, tow-in and caster.

Stability for the heaviest loads is provided by massive center steering arm, extra-heavy center arm stop blocks and heavy duty steering knuckle. Wide inside wheel turning angle assures maximum maneuverability and eliminates jack-knifing.

CARAVAN units are available in a variety of types and sizes in both 2 and 4-wheel assemblies for portable equipment weighing from 500 to 14,000 lbs. They are recommended for use with military and industrial as well as field service and construction equipment. 1123-UM

Write today for the new Bulletin No. 53 for further information.

UNITED
MFG. COMPANY
1114 INTERSTATE ST. • BEDFORD, OHIO

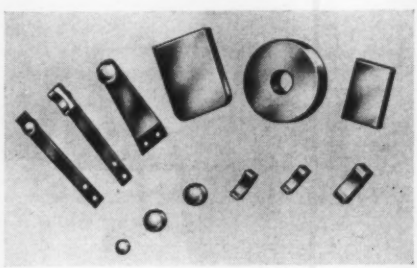
New Parts and Materials

tion and operate under conditions of extreme vibration, high temperature and humidity, and low voltage. There are only two moving parts which can be disassembled and serviced without removal from the line. Made by Skinner Electric Valve Div., **Skinner Chuck Co.**, Edgewood Ave., New Britain, Conn.

For more data circle MD-110, Page 207

Sliding Contacts

Low contact resistance and high resistance to welding are features of silver graphite sliding contacts and brushes for such equipment as servo mechanisms, radar antenna operating units, calculating ma-

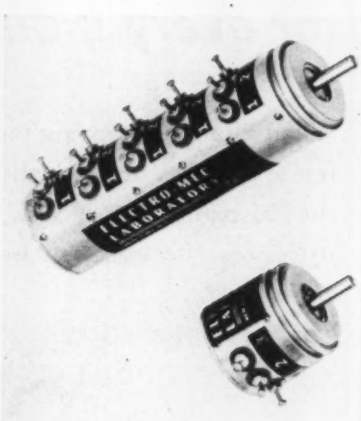


chines and midget motors. Extremely low noise levels are obtained by using units against silver ring. For ordinary uses, copper ring or commutator is sufficient. Available in diameters from 1/16-in. upward, units can be supplied with pure silver backing for easy spot welding or brazing directly to supporting arms or springs, as well as with copper backing integral rivet or other mounting device. Standard grades range from 5 to 80 per cent graphite. Made by **Stackpole Carbon Co.**, St. Marys, Pa.

For more data circle MD-111, Page 207

Potentiometer

Measuring 0.875-in. in diameter, the Type 9 ultra-low-torque potentiometer operates with a torque as low as 0.015-oz-in. Housing for the toroidally wound resistance element is of precision machined aluminum. The instruments are available in ganged assemblies up to six units. These assemblies are held together by internal clamps,



with no projections beyond the outside diameter. Individual cups can be phased separately. Mounting is synchro type with a locating boss for positioning the instrument. Rotation to any angle is possible, and numerous taps on any resistor element can be made, each electrically welded to a single turn of the winding. Standard linearity tolerance is 0.5 per cent, but 0.2 per cent can be maintained. Available in resistance values from 50 to 150,000 ohms from **Electro-Mec Laboratory**, 21-09 43rd Ave., Long Island City, N. Y.

For more data circle MD-112, Page 207

Magnetic Amplifiers

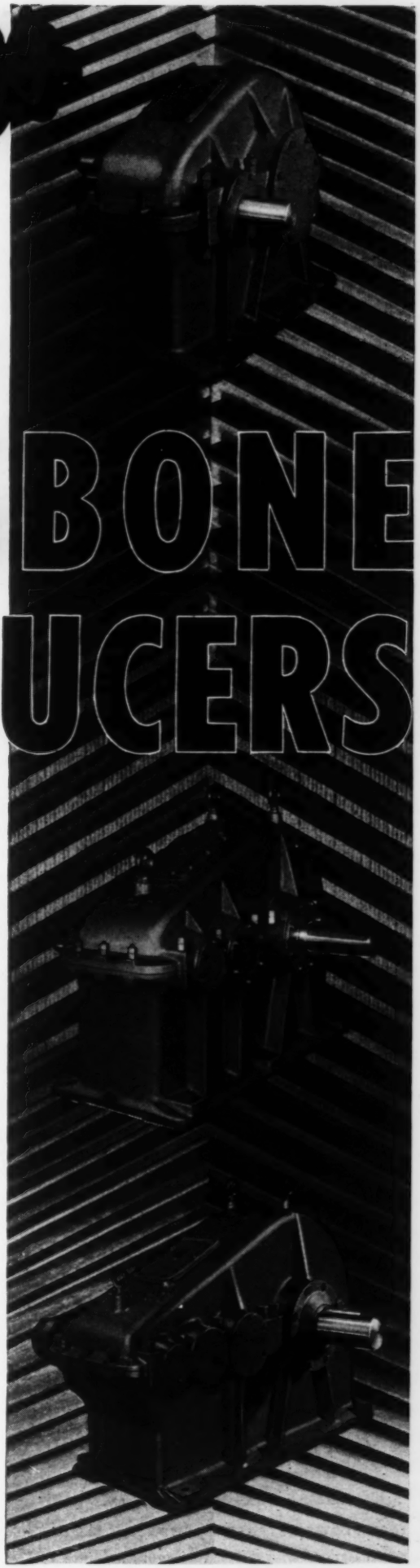
Special core materials, winding techniques and mountings and the use of high-frequency ac power make possible rapid response and

D.O.James

Established 1888

CONTINUOUS-TOOTH HERRINGBONE GEAR REDUCERS

The Gear with the Backbone



Some of the Many Proven *On-the-Job* Advantages of This Type of Gear Reduction Are as Follows

1. No side thrusts.
2. No avoidable deflections, distortions.
3. No necessity for bearings having thrust capacity.
4. Stronger teeth, due to the arch-like construction.
5. Greater load-carrying capacity due to utilization of the full width of face.
6. More silent and smoother action due to absence of distortion.
7. No impact stresses due to avoidance of sideways deflections.
8. Uniform load across face due to balanced thrusts of the opposing helices.
9. Better lubrication due to the oil film formed by "wedge action" of the teeth.
10. Less costly to produce due to the absence of side thrusts and no necessity for heavy sections to reduce deflections — also due to the simultaneous utilization of two cutting tools.
11. Can be substituted for straight tooth gears without any change in design of bearings or housings, or increase in face width, or alteration in pitch.
12. No axial float is necessary because the "V" shaped herringbone teeth wedge automatically into the mating gear thus eliminating all sideways motion and the consequent rubbing action of a screw-like nature existing in single helical gears which result in pitting and wear at relatively low loads.
13. Less expensive gear housings and bearing housings due to balanced thrusts.
14. Large helical angles are used; thus the full benefit of the helical principle is obtained.
15. Tooth deflection, though very small, results in the greatest load being carried by the strongest section.

All Gears are Generated Continuous-tooth Herringbone Gears, 20° pressure angle, 30° helix angle

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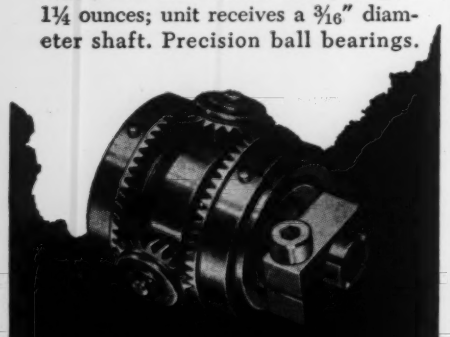
Hollow Shaft Differential

Minimum weight, inertia, and backlash. A precision computer component. Designed for accurate resolution of angular position or velocity sums and differences. Hollow shaft design offers complete freedom of positioning of differential on shaft and facilitates installation-removal of differential from shaft without instrument disassembly. Shrink-on, safety-keyed side gears available to your specifications. Inertia: .0745 ounce-inch^2; maximum backlash: 10′; overall axial length: 1$\frac{3}{16}$″; clearance radius: .520″; weight: 1¼ ounces; unit receives a $\frac{3}{16}$″ diameter shaft. Precision ball bearings.



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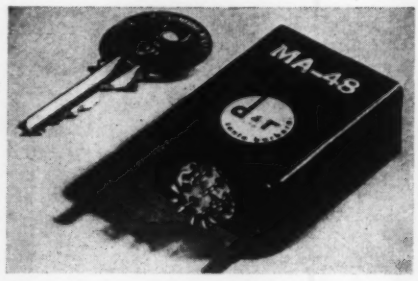


high power handling capability in series of 4000 and 2000-cycle miniature magnetic amplifiers. Model MA-48, illustrated, weighs 3 oz and delivers a 25-w power output. Manufactured by **D & R Ltd.**, 402 East Gutierrez St., Santa Barbara, Calif.

Elapsed Time Meter

For more data circle MD-113, Page 207

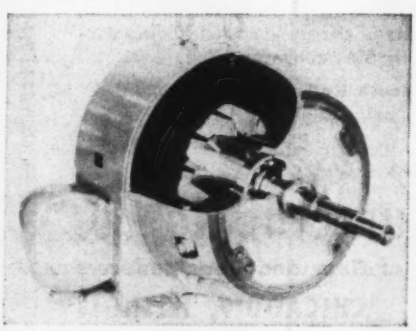
Impregnated Leather

Porosity of leather seals and packings is controlled in Conpor elastomer-impregnated leather. Retaining the good properties of leather, the oil seal and hydraulic packing material has flexibility, strength, stability, resistance to oils and solvents, flexibility at low temperatures and ages well. Leathers are available in a range of porosities from 0 to 100 per cent and in full thickness or limited-depth impregnations. Impregnant used is Thiokol liquid polymer. Made by **Chicago Rawhide Mfg. Co.**, 900 North State St., Elgin, Ill.

For more data circle MD-114, Page 207

Pump Motor

Available in models which develop up to 60 hp, this motor is designed for use with centrifugal pumps. The pump is supported on an NEMA style C mounting bracket. A step shaft, with special diameter, shoulder and tapped hole for mounting the impeller, has all ground diameters for precision assembly and sealing against leakage. Grease lubricated ball bearings permit installation vertically, horizontally or at any intermediate angle. Liquid being pumped cannot enter the motor. Made by **U. S. Electrical Motors Inc.**, P. O. Box 2058, Terminal Annex, Los Angeles 54, Calif.



For more data circle MD-115, Page 207

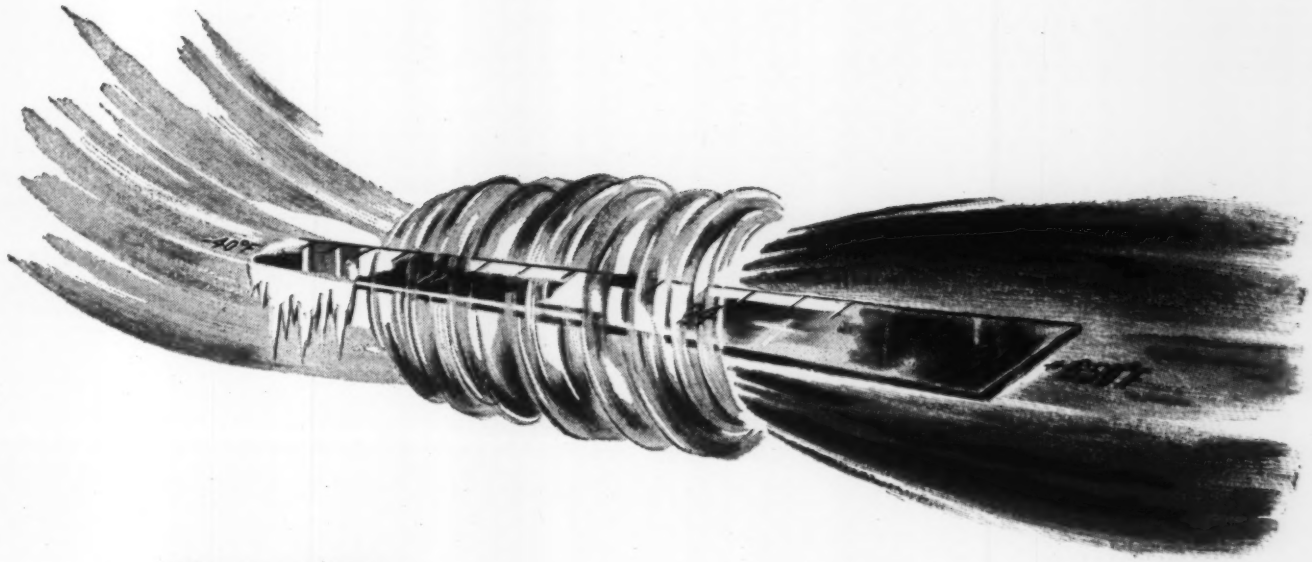
Time Switch

Replacing present 300 series unit. Memory Master 3000 series time switch has easily-read day-night dial. Dial trippers need only be loosened slightly for resetting. Additional trippers can be added without removing the dial to provide up to 16 operations in a 24-hour period. Torsion clutch permits free movement of dial for manual check of the "on-off" switching operations. The unit is housed in gray 18-gage drawn steel case. It is UL-approved for 30 amp at 120 or 240 v. Made by **Paragon Electric Co.**, Two Rivers, Wis.

For more data circle MD-116, Page 207

Die-Cut Parts

Size and relative location of pierced holes are accurate to +0.001-in. when die-cut parts are



IN 3 FEET WE CHANGE AN ARCTIC GALE INTO A VOLCANO

...it may hold an idea YOU can use!

You can almost *see* the metal *wanting* to protest. Super-frozen by arctic cold at the intake. Super-roasted at the outlet, only a yardstick's length away. And rotating 10,000 times a minute miles high in the air in an aircraft jet engine.

The Jet Division has a broad knowledge about commercial metals, including some you may not have used yet. We also know a lot about combinations of metals and how to make one work happily with another to lick once-insurmountable problems in unusual applications. We can also engineer and produce unusual assemblies that use these metals.

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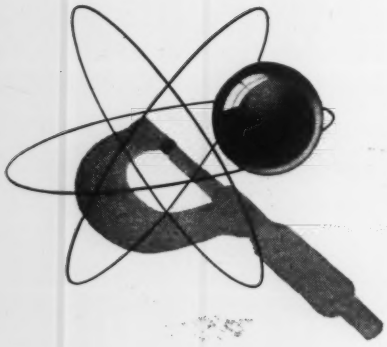

round all over!

Universal Precisioneered Balls are true spheres, round all over, within tolerances of ten-millionths of an inch. Mirror-smooth, they are silent in operation, with minimal torsional resistance, even at high speeds.

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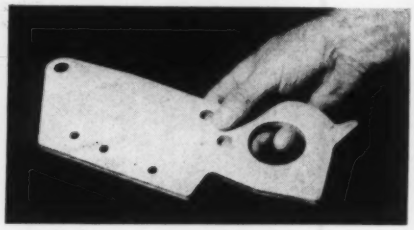
produced by an improved method. Sheet and alloy steel, nonferrous sheet materials including fiber and bakelite and all other sheet stock



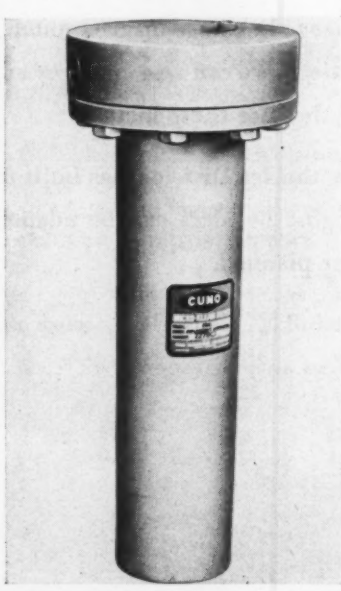
that can be stamped, in almost any gage and from 0.001 through 3/8-in. thick, can be blanked and pierced to desired shape and size. Developed by **Dayton Rogers Mfg. Co.**, Minneapolis 7, Minn.

For more data circle MD-117, Page 207

High-Pressure Filter

Available in standard units for operating pressures up to 1000 psi, high pressure liquid and gas filters have been added to the Micro-Klean line. Units for higher pressure service are also available. Construction is all-welded steel with headpiece machined from bar stock. Pipe sizes for inlet and outlet are 3/8, 1/2 and 3/4 in. Filtration degrees are 10, 25, 50 and 75 microns. Maximum liquid capacity at 150 SSU, 2-lb pressure drop, and 50-micron degree of filtration is 15 gpm. For gases at 1000 psig, 2-lb pressure drop and 25 degree micron filtration, maximum capacity is 200 scfm free air. Made by **Cuno Engineering Corp.**, 80 South Vine St., Meriden, Conn.

For more data circle MD-118, Page 207



Small Storage Cells

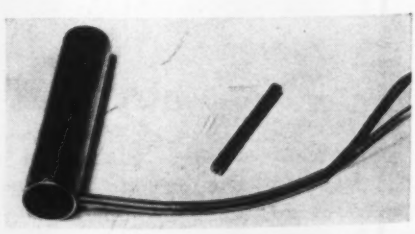
Featuring high discharge currents, models HR85 and HR90 silver-zinc alkaline cells are rated conservatively at 100 amp-hr. Spill-

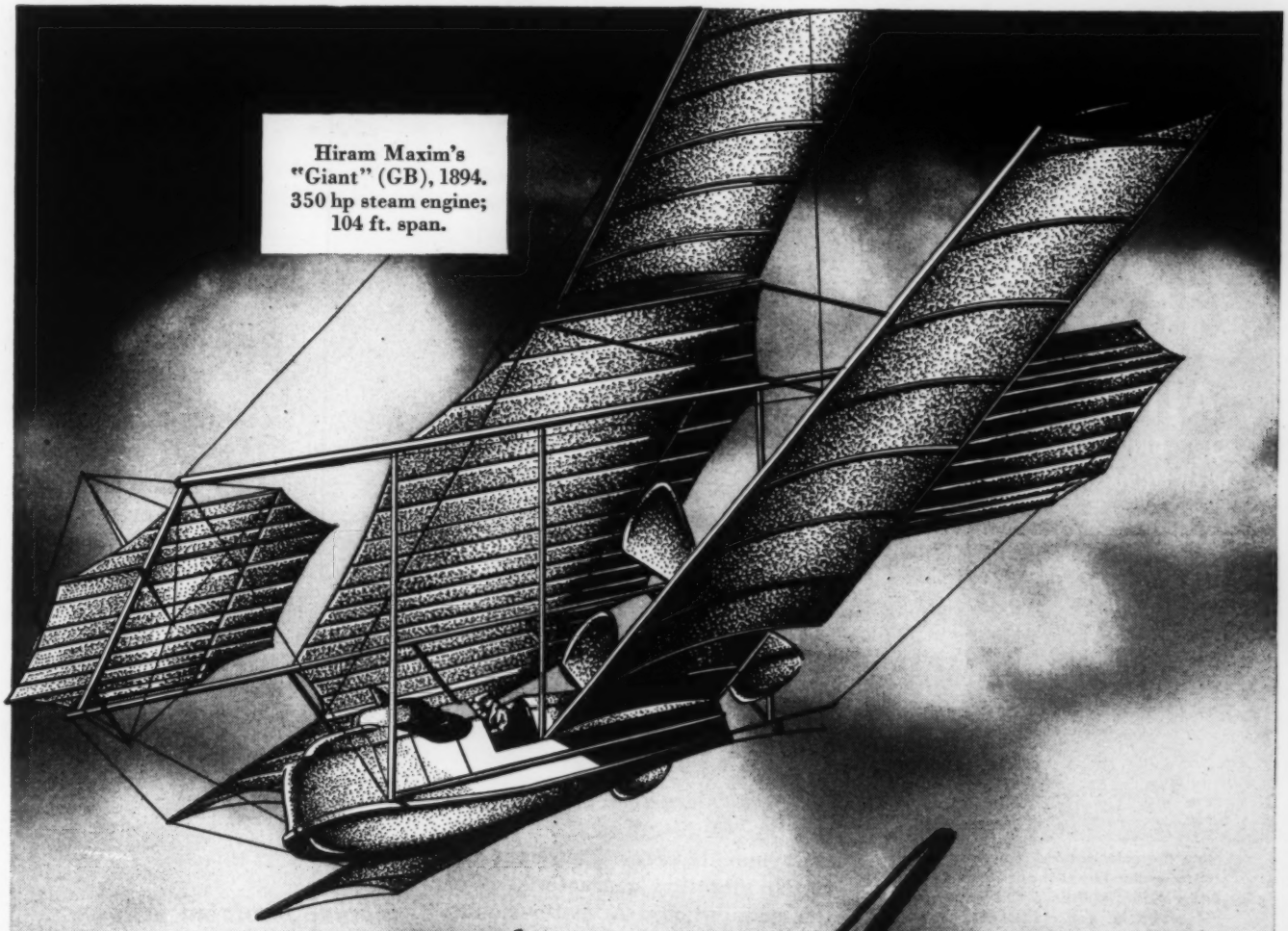
proof and efficient, these units operate under extreme conditions of shock, vibration and acceleration. Applications include motion picture cameras, portable television cameras, mineral locating devices and self-contained jet aircraft starters. Made by **Yardney Electric Corp.**, 105 Chambers St., New York 7, N. Y.

For more data circle MD-119, Page 207

Velocity Pickoffs

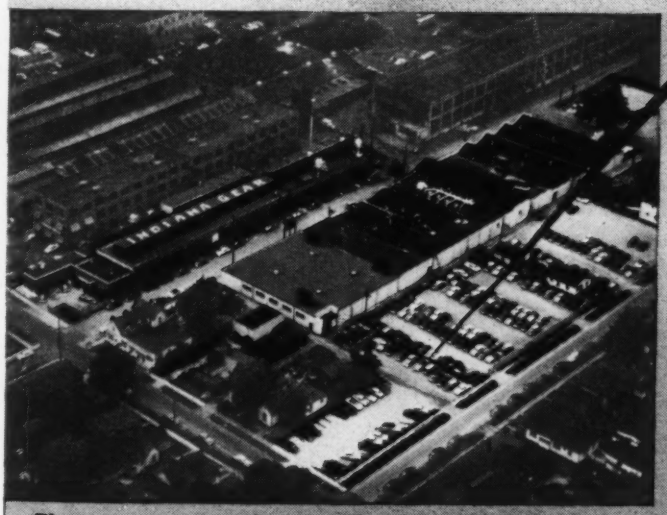
Series of shockproof high sensitivity linear motion velocity pickoffs, LVsyns, are shielded cyl-





Hiram Maxim's "Giant" (GB), 1894. 350 hp steam engine; 104 ft. span.

...out of this came Aviation



The manufacturing facilities of IGW at Indianapolis

An industry whose tremendous growth has forced the continued expansion of the manufacturing facilities of many companies to feed this great industry's carnivorous appetite for production.

Indiana Gear Works is such a company—we began to produce precision parts for the aviation industry in 1933.

Today, twenty years later, we find ourselves continuing to increase our physical plant in order to gain the production capacity we need to consistently produce quality precision parts and assemblies.

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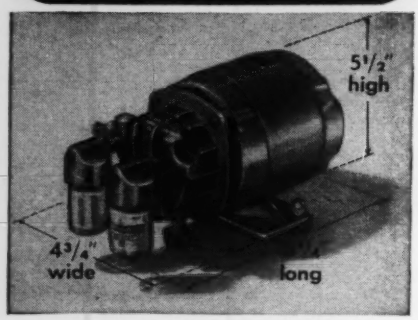
FOR ORIGINAL EQUIPMENT
APPLICATIONS AND PORTABLE USES



Note the compactness! Yet these Integral Motor-Pumps (basic Model No. 0406 shown) deliver .6 CFM—to 15 PSI or 25 In. Vac. 1750 RPM with 1/12 HP G.E. Motor.

It's a VACUUM PUMP! For vacuum, Model 0406-V2-154X has already proved its advantages as a component of industrial instruments requiring air flow; as a portable air sampler, etc.

It's an AIR COMPRESSOR! For pressure, Model 0406-P2-154X is in use on special machines for textile wear testing; as a laboratory compressor, etc.

Both OIL-LESS AND STANDARD LUBRICATED TYPES OFFERED - VARIOUS ACCESSORIES

You can get absolutely oil-free air with completely oil-less models (*never* need lubrication); also standard lubricated models. Altogether, Gast offers a wide range of Integral Motor-Pump Models from 1/12 to 1/3 HP. *Investigate now!*

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FOR NEW DATA SHEETS on 0406 Integral Motor-Pump Models.

Same model, but with handle, gauges, nipples, etc., to show typical accessories we can furnish.

Original Equipment Manufacturers for Over 25 Years

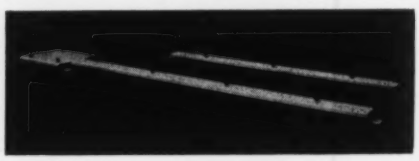
GAST ROTARY
AIR MOTORS (TO THREE H.P.) · COMPRESSORS (TO 30 LBS.) · VACUUM PUMPS (TO 28 INCHES)
GAST MANUFACTURING CORP., 107 Hinkley St., Benton Harbor, Mich.

indrical coil assemblies having coaxial holes and cylindrical high coercive force permanent magnet cores. The magnet core is free to move in the coaxial hole which runs the full length of the coil assembly. Relative velocity of the core with respect to the coil assembly results in the output signal. Maximum displacement ranges from a few thousandths of an inch to several inches. Sensitivity is a function of the size of the pick-off. Model 6V8 has a 1-in. stroke and sensitivity of 450 mv per inch per second. Made by **Control Components Co.**, 46 Walnut St., Brookline, Mass.

For more data circle MD-120, Page 207

Isolation Bases

Held between steel members that run the full length of the machine, Barrymounts carry the weight and match vibration characteristics of the installation. A motor-mounting plate is incorporated in one member to keep the motor and fan pulleys the same distance apart for steady drive and reduced belt

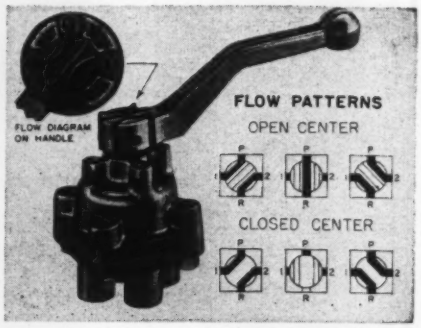


wear. Bases are designed and built to individual performance requirements. Made by the **Barry Corp.**, 700 Pleasant St., Watertown 72, Mass.

For more data circle MD-121, Page 207

Hydraulic Valves

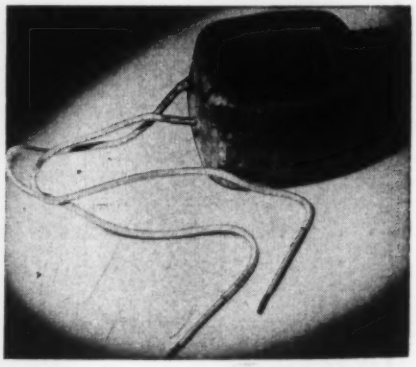
For 1500 psi oil service and available in pipe sizes from ¼ to 1 in., Shear-Seal manual hydraulic valves feature leakproof closure, low handle load and good throttling. They are also resistant to freeze-ups and are not critically affected by dirt in the line. Standard models can be bracket or panel mounted, and the straight porting of the four-way series provides for manifolding with standard tees in the pressure and return ports. Position stops and detents are fully enclosed, and a flow diagram on the handle indicates the flow for all operating positions. Spring centering and a positive locking device are standard accessories. Made by **Barksdale Valves**, 5125 Alcoa Ave., Los Angeles 58, Calif.



For more data circle MD-122, Page 207

Silicone Insulated Wire

Flexibility of Sil-X glass braid-lacquered wire with General Electric SE-460 silicone rubber insulation is retained at minus 60 F. Physical and electrical properties are also maintained at temperatures as high as 400 F. Wire resists flex cracking and has low dielectric constant. Insulation is fungus resistant. Six sizes are available, UL-approved for use in lighting fixtures up to 200 C and for radio and television hookup

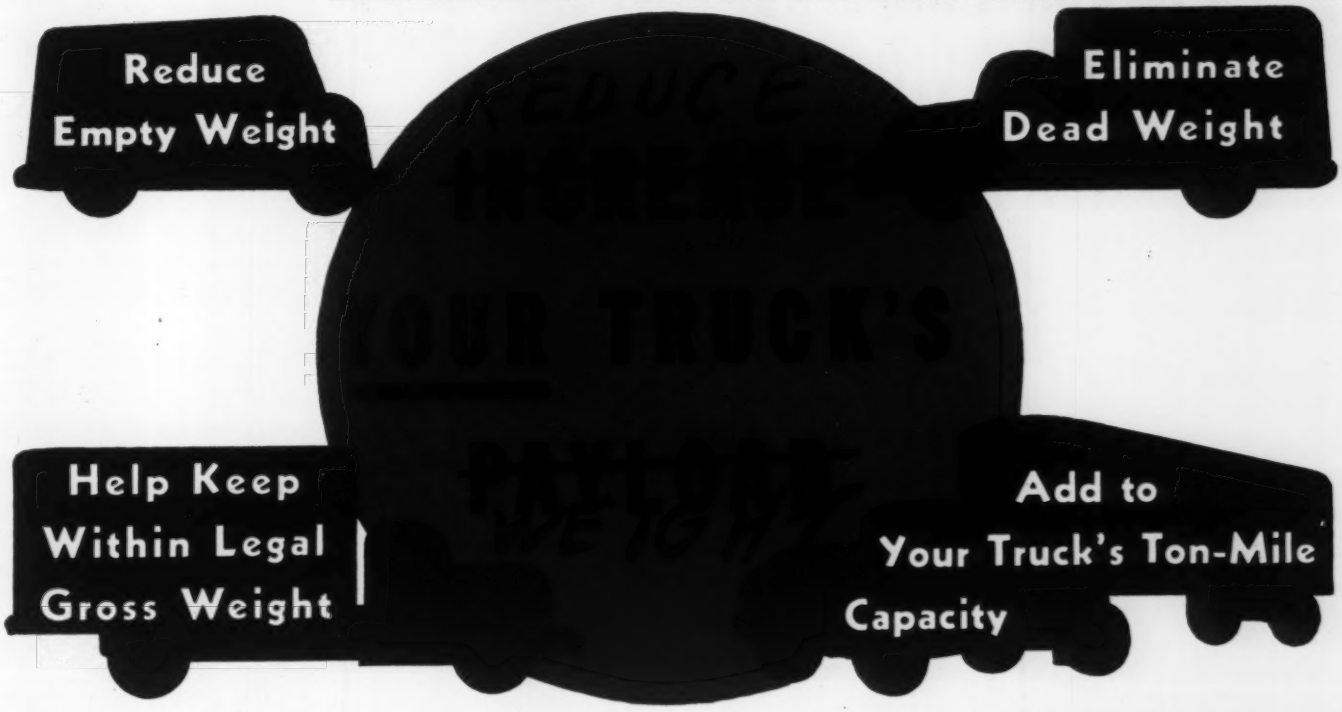


wire up to 150 C. Manufactured by **Essex Wire Corp.**, Ft. Wayne, Ind.

For more data circle MD-123, Page 207

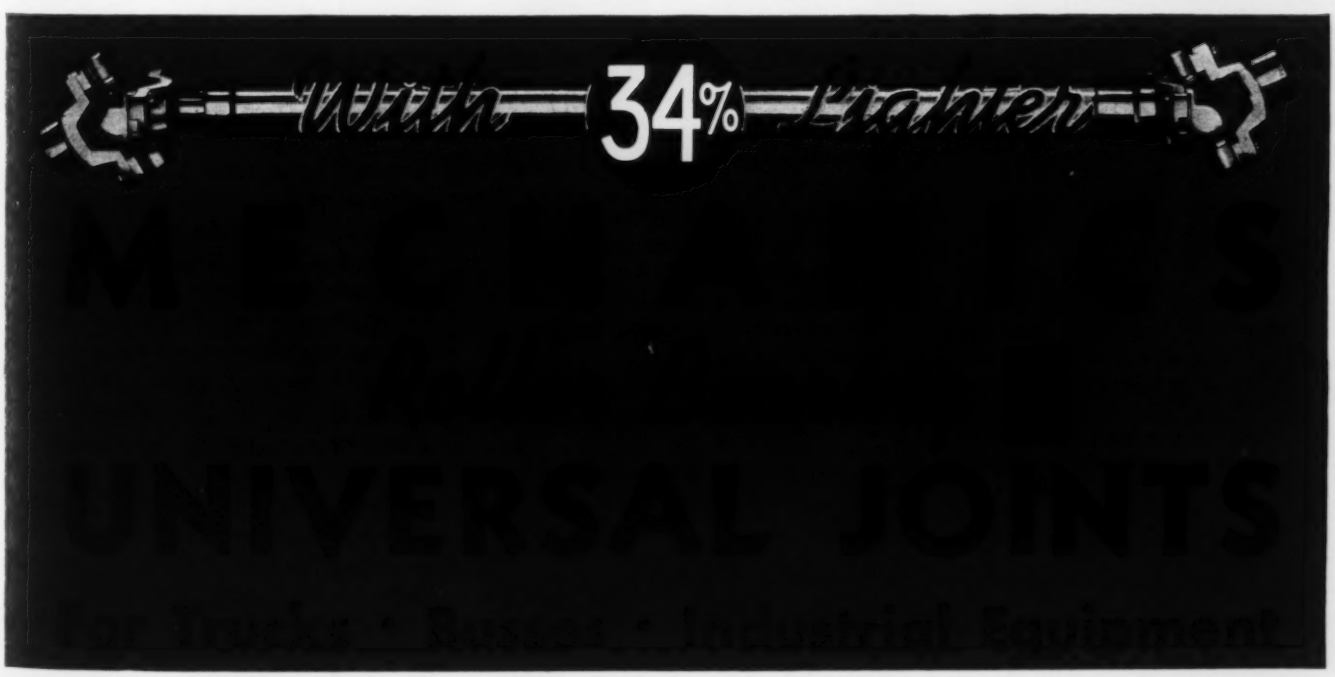
FLASH .... FLEET OPERATORS ARE PAYING A PREMIUM

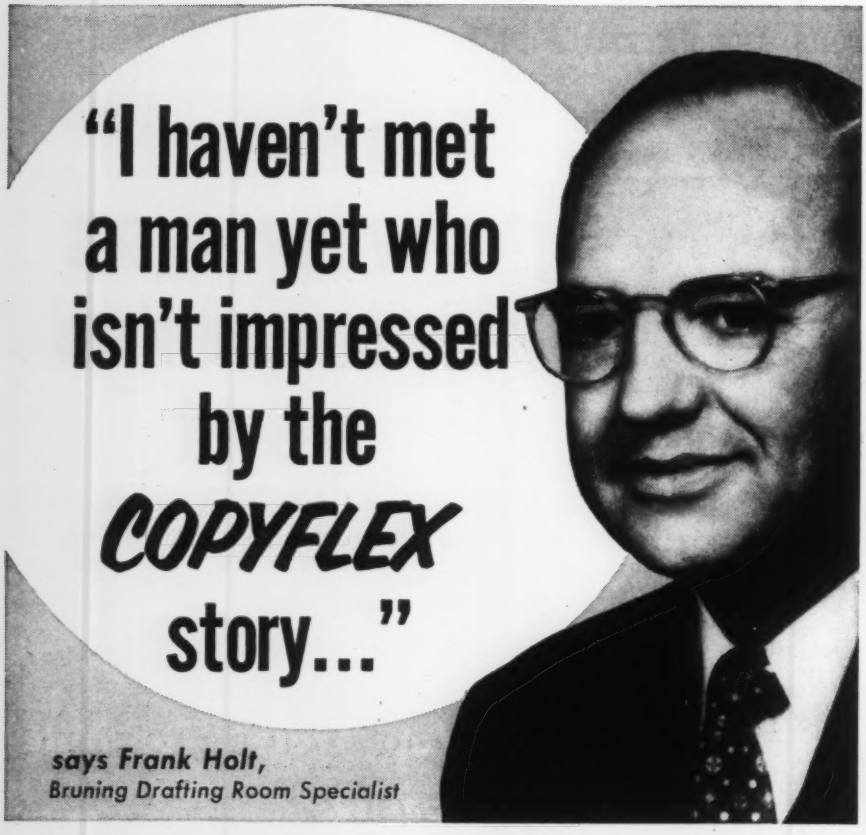
OF ONE DOLLAR PER POUND FOR REDUCED TRUCK WEIGHT



A truck manufacturer says big fleet operators are offering $1.00 per pound for reduced truck weight — and that the use of lighter metals has reduced weights down to their lowest achievement point — within acceptable standards of life and wear. Because MECHANICS Roller Bearing UNIVERSAL JOINTS truck PROPELLER SHAFT is pounds lighter than other joints and shafts of comparable torque capacity — you can reduce the weight of *your* truck by specifying MECHANICS. Let MECHANICS engineers help reduce the weight and increase the payload capacity of *your* truck — and give it a competitive weight advantage — with a MECHANICS Roller Bearing UNIVERSAL JOINTS truck PROPELLER SHAFT application.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2032 Harrison Avenue, Rockford, Illinois





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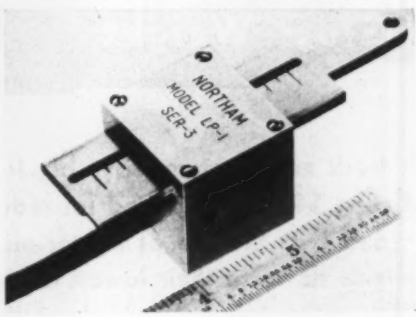
ENGINEERING DEPARTMENT

EQUIPMENT

Linear Position Transducer

Remote measurement and recording in aircraft and engine test and design work are possible applications of Northam model LP-1 linear position transducer which converts linear motion or position into a proportional electrical signal. Based on magnetic reluctance principle, unit will operate



in alternating current carrier systems from 60 to 10,000 cycles accurate within 1 per cent of range and with virtually unlimited resolution. When operated in bridge circuit, full scale output is ±40 mv per volt, and maximum excitation is 7 v. Standard slide travel ranges are from ±½ to 2 in. Hermetically sealed model for extreme ambient conditions is available for process control and rocket testing. Made by **North American Instruments Inc.**, 2420 North Lake Ave., Altadena, Calif.

For more data circle MD-124, Page 207

Electronic Timer

The Millisecond Glow Transfer Timer measures elapsed time by counting pulses from an electrically driven, 1000-cycle precision tuning fork. Self contained, the instrument does not require an ex-

ternal source of frequency control. Count is indicated on the dial by means of bright glows which point to numbers around the periphery of glow transfer decimal counting tubes. A separate tube is provided for each decimal place. Range is 99.999 seconds in 0.001-second increments. The instrument is accurate to 0.001-second or 0.008 per cent, whichever is larger. It operates on 105 to 125-v ac, 50 or 60-cycle, 40-w power. Available in four different models, the timer can be controlled manually or by external means such as switch contacts, relays, or pulses originating in other equipment. For pulse operation, special circuitry is required and separate models are available for this purpose. Cabinet measures 10½ in. wide, 13 in. deep and 9 in. high. Made by **Instrument Laboratory Service,** 10701 Briggs Rd., Cleveland 11, O.

For more data circle MD-125, Page 207

Analog Stimulus Generator

Model CS Central Signal Component is used in high-speed repetitive analog computing systems to initiate time solutions and to assist in organizing, operating and calibrating such systems, as well as in the display of their results. A fixed time base of 20 cycles per second is employed, affording a 40-millisecond computing interval. Three internally synchronized signals are available. The "clamp" signal holds a system artificially stabilized prior to stimulation; the "ramp" signal provides a linear time-base, covering

SPACE COSTS MONEY

These pumps permit...

- **SMALLER CABINETS**
- **LOWER CABINET COSTS**

LOW NARROW and HANDSOME

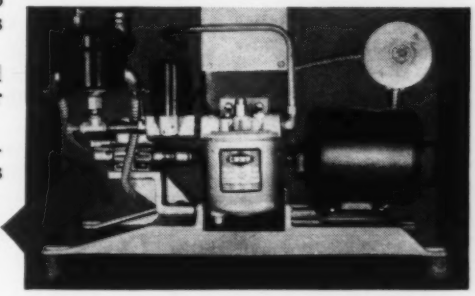
COMPACTNESS—Another bonus for manufacturers who build their machines, devices or appliances around ECO PUMPS.

If you use pumps in your products, you'll find price is not the major factor in over all profit—although high quality Eco Pumps are competitively priced.

You'll find that these more efficient pumps permit smaller, lower-cost motors. Directly connected, in most cases, they eliminate expense of intermediate driving equipment. This smaller, close-coupled motor and pump assembly also cuts down space requirements to a minimum, permits savings in over-all cabinet costs and improves product appearance and adaptability.

Get Eco Economy. Ask the leaders in small pump production. A unique engineering service is at your disposal to match pumps to specific problems.

- Positive displacement type with two opposed, axially-oscillating impellers equivalent to duplex piston action.
- Pressures to 150 psi. Capacity to 10 GPM. High suction lift. Self-priming. Non-foaming. No air entrainment. Continuous non-surging flow.
- Operate in any position and submerged, pumping high or low temperature fluids.
- Impellers of synthetic rubber, plastics, Teflon or porous metals for all requirements.



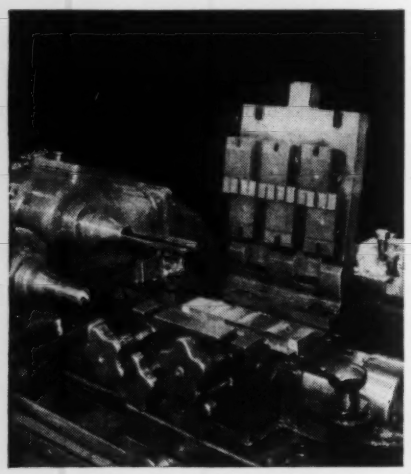
ECO Engineering Company
12 New York Ave.
Newark 1, N.J.

ECO fluid engineering

FIXTURE DRILLING with DEEP HOLE DRILLS

faster feeds • greater accuracy • less handling

More and more metal working plants are discovering how Hi-Standard Deep Hole Drills cut costs and produce more accurate results in drilling many pieces at once.



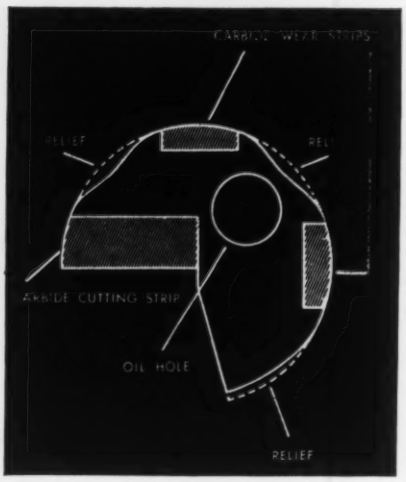
Gang drilling in fixtures

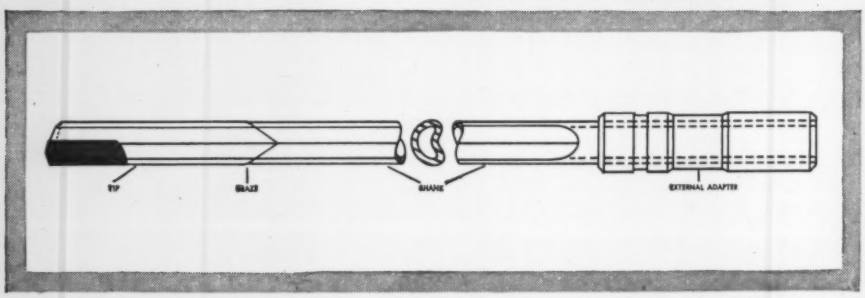
This method of "fixture drilling" many parts ganged together in one fixture cuts handling and drilling time considerably. By using forced oil feed through the drill, fast drill feed is permitted because it doesn't have to be withdrawn to clear chips. The constant oil flow cools the cutting edge and washes out chips to assure a smooth hole to size.

Fixture Drilling is effective for drilling a single heavier unit. The pressurized oil feed permits revolving *the drill*, rather than *the part*, and a light stationary fixture is adequate to hold the part.

Versatility with accuracy

All kinds and sizes of parts are being drilled *faster and more accurately* with both high speed and carbide tipped deep hole drills. Successful fixture drilling is performed on automatic indexing machines, lathes and similar equipment as well as both horizontal and upright deep hole drilling machines.



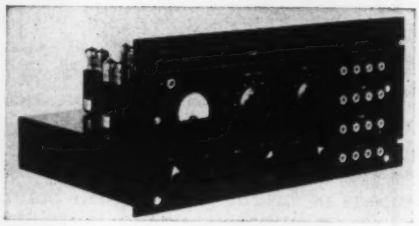


To discover how Hi-Standard Deep Hole Drills can boost your production, write today for literature, which describes both fixture and deep-hole drilling.

THE HIGH STANDARD MANUFACTURING CORP.
HAMDEN, CONNECTICUT

Engineering Equipment

the entire 50-millisecond interval, for plotting and scanning purposes; and the "step" signal is automatically delayed following removal of the clamp—it is adjustable from 0 to 50 v positive or negative, and may be retracted to form a square pulse of 0 to 30 milliseconds width.

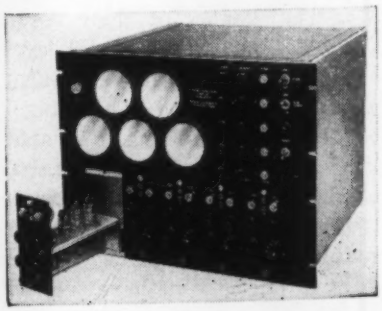


A binary reversing system alternates optionally between positive and negative step stimuli on a 10-cycle base. Power requirements are plus and minus 300 v dc at 60 ma each, and 115 v ac at 0.7-amp. Made by **George A. Philbrick Researches Inc.**, 230 Congress St., Boston 10, Mass.

For more data circle MD-126, Page 207

Oscilloscope

A five-channel unit designed for relay rack mounting permits measurement of mechanical vibrations up to a frequency of 100,000 cycles per second with flat response from dc to 50,000 cycles. Each of the five channels has a separate, well ventilated plug-in amplifier. Identical amplifiers are interchangeable. Input connections may be made on either the back or front panel. The power supply, which has regulated outputs, is accessible and can be removed from the rear of the unit. Push-pull amplifiers in each channel apply strain gage outputs to the individual cathode ray tubes. The



How to pick the packing with UNIFORMITY needed for tighter seals

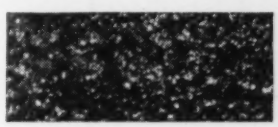
1 Be sure it's made right

Houghton's special synthetic rubber moulding process results in a more compact, uniform structure and greater density, which assures longer packing life. These photomicrographs show the difference.

Cross-section of average compound

Coarser, less dense pattern of rubber is indicated in this photomicrograph of a standard packing compound, magnified 240 diameters. Note lack of uniformity.

Cross-section of Vix-Syn compound



Fine-grain density of rubber throughout Houghton Vix-Syn Packing is shown in this cross-section similarly magnified. This compact, homogeneous quality means longer packing life.

2 Be sure it's designed right

Houghton engineering service begins at the drafting board, rendering needed aid to machine designers seeking the type and size of packing rings and adapters best fitted to hold pressures effectively.

3 Be sure it's Houghton VIX-SYN

You can always be sure of getting the packing stability and uniformity you need, by specifying VIX-SYN rubber packings and "O" rings. Their resistance to heat, oils, solvents and gases means longer packing life over a wide range of pressures and temperatures. Increased manufacturing facilities mean prompt deliveries. For full details, ask the Houghton Man, or write E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa.

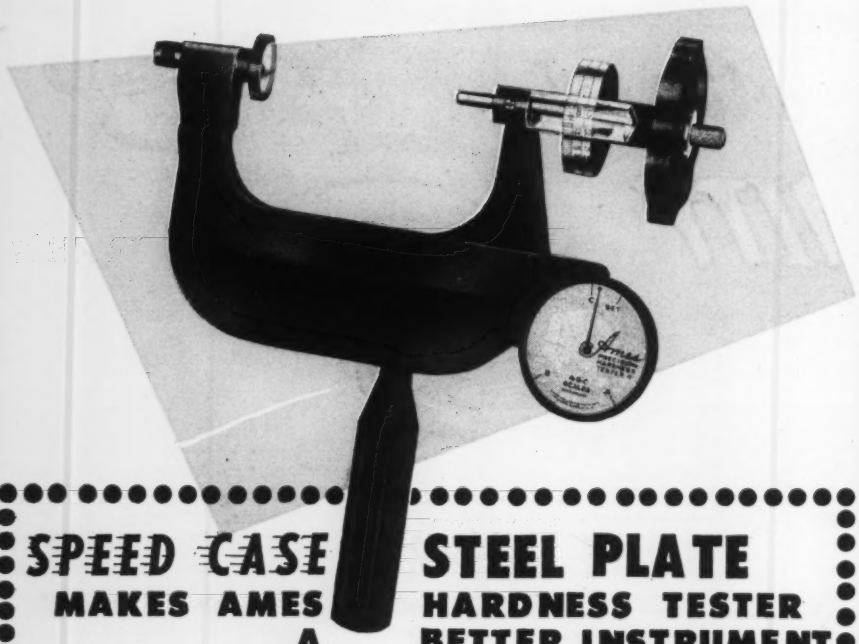
VIX-SYN Packings

...a product of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

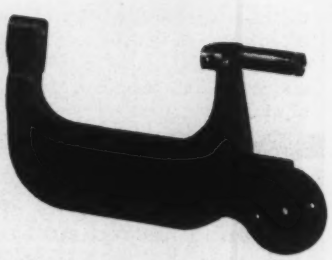
Ready to give you on-the-job service . . .



SPEED CASE STEEL PLATE MAKES AMES A HARDNESS TESTER BETTER INSTRUMENT

A Model 4 Ames Portable Hardness Tester manufactured by Ames Precision Machine Works, Waltham, Mass. is shown above. The dial is direct reading, indicating Rockwell A, B or C scale hardness on thicknesses up to 4".

Frame of the Ames Model 4, and several other models, is machined from **Speed Case** (X1515) low carbon, open hearth steel plate, supplied in flame cut blanks, as shown at right. The machined frame is shown in lower view, after magnifier retaining arm (1) and dial support (2) have been silver soldered to frame.



Speed Case has proved ideal for this application for three reasons: (1) Available flame cut to close tolerance. (2) Ease of machining, longer tool life, more readily polished and (3) Superior physical properties rendering it more suitable for a precision instrument.

Probably one of the **Speed Steels—Speed Case, Speed Treat** or **Speed Alloy**—can cut your costs while improving your product. **Send for literature.**

Speed Steels

SINCE 1856 W. J. HOLLIDAY & CO. (INC.)

SPEED ALLOY • SPEED CASE • SPEED TREAT

DISTRIBUTED BY

Brown-Wales Co., Cambridge-Hartford-Auburn, - Bridgeport Steel Co., Milford, Conn. Beals, McCarthy & Rogers, Buffalo, N. Y. - Burgef Iron Co., Akron, Ohio - Grammer, Dempsey & Hudson, Inc., Newark, N. J. - Earle M. Jorgensen Co., Los Angeles-Houston-Oakland-Dallas - Passaic County Steel Service, Inc., Paterson, N. J. - Peckover's Ltd., Montreal-Toronto - Peninsular Steel Co., Detroit, Mich. - Pidgeon-Thomas Iron Co., Memphis, Tenn. - Horace T. Potts Co., Philadelphia-Baltimore-York, Pa.

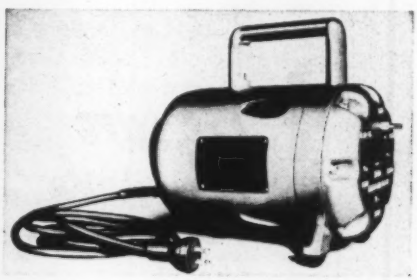
Produced by W. J. Holliday & Co., Inc., Speed Steel Plate Division, Hammond, Indiana. Plants: Hammond and Indianapolis, Indiana

tube arrangement permits direct comparison of five simultaneous vibrational effects and photographic recording on one 35 mm film. A neon marker light provides a time base reference. Made by **Franklin Electronics Inc.**, 415 West Pike St., Philadelphia 40, Pa.

For more data circle MD-127, Page 207

Tachometer Tester

Operating on 115 v, 60 cycles, Model 1100 has seven output speeds of 300, 500, 600, 720, 800, 1000 and 1800 rpm, for testing most types of portable tachometers. A built-in reversing switch



permits clockwise or counterclockwise rotation of the shafts for testing tachometers in either direction. For a comparative reading, the driveshaft of the tachometer is inserted into the desired speed shaft on the tester. Portable, the unit weighs 23 lb. Made by **B. K. Sweeney Mfg. Co.**, 1601 23rd St., Denver 17, Colo.

For more data circle MD-128, Page 207

Circular Chart Recorders

Available for six or 24-point recording and as ac self balancers or as Tektologs, these recorders are equipped with six-point turret pens which provide six different colored traces. The full print cycle for six points, on the standard unit, is accomplished in 30 seconds. The 24-point print cycle, on standard units, is accomplished in two minutes. A combination of six-point and segmental recording is possible on the 24-point recorder. The circular chart is divided into

Two World-Famous
Organizations Become One — *and*

this is what happens...

Just a few years ago, National Pneumatic, the world's leading producer of transit and railroad safety equipment, and Holtzer-Cabot, a pioneer and leader in the electrical field, became one organization.

Manufacturing was consolidated at the big Boston plant of Holtzer-Cabot. Progress was swift and sure in both companies' ability to serve customers even better.

SIX DIVISIONS WERE SET UP

Transit and Railroad • Industrial Activators and Controls • Products for National Defense • Motors • Telephone • Automatic Doors

All the familiar products, plus many new ones are now being made under a new high efficiency. Design and Research Departments have grown on a full scale to match the increased activities of these two great companies — with some left over!

To industry this is a new, large and dependable resource. Research, development and manufacturing facilities are available for mechanical, pneumatic, hydraulic, electric and electronic products either singularly or combined. Inquiries on present products or development work are welcomed.

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cold-forged

Precision Cap Screws

● Wherever shear, stress or vibration is encountered, **CHANDLER** cold forged metal fasteners assure perfect performance. Uniformly accurate, they speed assembly operations.

The quality and precision of **CHANDLER** cap screws can be measured by their wide use in major industries. **CHANDLER** fasteners are used by leading manufacturers of gasoline, jet and diesel engines designed for automobiles, aircraft and heavy equipment.

Whatever your requirements, specify **CHANDLER** precision cold forged cap screws.

- Grinding to Close Tolerances
- Drilled Heads or Shanks

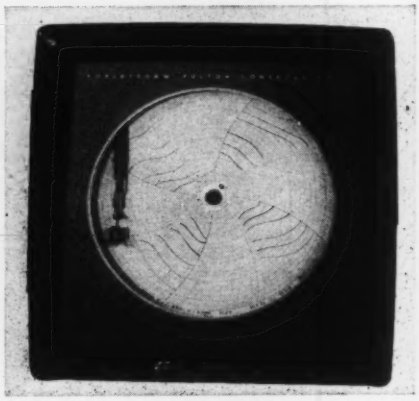
1304-CH

Specialists in Thread-Rolling After Heat Treating

CHANDLER PRODUCTS CORPORATION

1494 Chardon Road, Cleveland 17, Ohio

Engineering Equipment

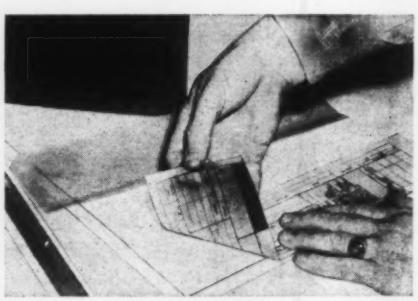


four segments, each equivalent to either 8 hours, 24 hours or 7 days. On each segment, six different colored traces are drawn. On-off control can be provided on all points. When the cycling mechanism is switched off, the recorder operates as a normal single-point recorder. Made by Fielden Instrument Div., **Robertshaw - Fulton Controls Co.**, 2920 North Fourth St., Philadelphia 33, Pa.

For more data circle MD-129, Page 207

Printed Plastic Legends

Title blocks, bills of material, change blocks, technical and any other specified symbols may be printed on Transeals for use on drawings and tracings. They eliminate rubber stamping and hand lettering, symbol drawing and ruling for drawings made on paper,



vellum or cloth. Furnished for application by adhesion to either the reverse side or the face of drawings, they are applied by light hand pressure. Coating is protected by a waxed paper sheet before use. Developed by **Johnson Research Corp.**, Bethpage, N. Y.

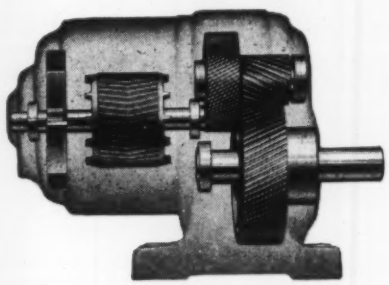
For more data circle MD-130. Page 207

(Advertisement)

Machinery Design Improved With Slo-Speed

We have used Slo-Speeds for years on many types of special machinery we manufacture and can report complete satisfaction with their performance, states Frank Fluckinger of Fluckinger Machine Works, Seattle. Their streamlined design enhances the appearance of our equipment ... their compact, self-contained construction and versatile mounting features facilitate installation, add to safety in operation, and make them adaptable to our varied requirements.

STERLING SLO-SPEED



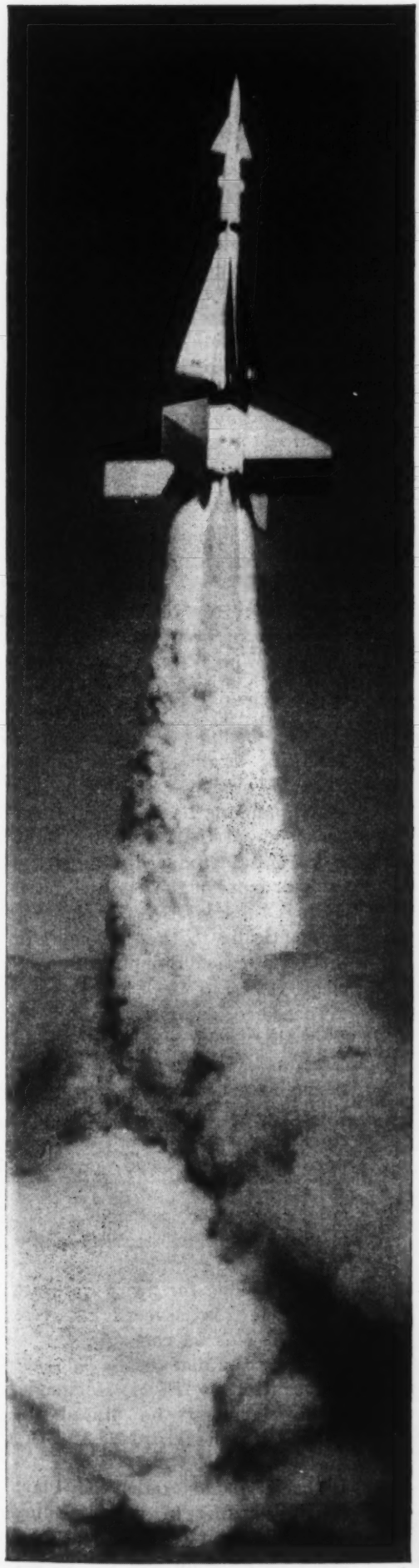
OUTSTANDING FEATURES:

Simplified gear system — balanced design — compact — rugged — highly efficient — abundant lubrication — low output shaft — positive oil seals — Herringbone Rotor — protected — streamlined — direct through ventilation — quiet operation — AGMA speeds — extremely long life — every unit will operate in any position.

20-page illustrated catalog ... Sterling Speed-Trol, Slo-Speed, Klosd and Klosd-Tite Electric Power Drives. Write for catalog No. I-D-424

STERLING ELECTRIC MOTORS

Plants: New York City 51; Chicago, Ill.; Los Angeles 22; Hamilton, Canada; Santiago, Chile
Offices and distributors in all principal cities



Photo, Courtesy Douglas Aircraft Company, Inc.

Inco precision cast these gyro gimbal parts for Kearfott Company, Inc., from SAE 8620 steel. The parts are made to a tolerance of plus or minus .005 inch per linear inch and require very little finish machining. The cost of fabrication by conventional methods would have been prohibitive.

What Keeps a Guided Missile on Course?

It's the precision gyro that stabilizes missiles, target drones and jets and keeps them headed true.

These gyros are exposed to temperatures ranging from −65° F. to +203° F. Naturally, the gyros have to be built to operate perfectly throughout this range. So that all the working parts may expand and contract evenly, they must be made of the same metal.

One of the leading manufacturers of these gyros is the Kearfott Company, Inc., of Little Falls, N. J. Kearfott engineers have found that the most satisfactory metal for these parts is SAE 8620 steel.

But to fabricate the gimbal parts by conventional methods would be prohibitively expensive.

That's where Inco stepped into the picture and suggested precision investment casting.

Inco precision-cast the gimbal parts to a tolerance of plus or minus .005 inch per linear inch. The only machining necessary was at critical areas; result—proper alignment and virtually no friction. Then the parts were ready to be drilled for mounting.

In comparison with other methods, the job was done in less time and at a fraction of the cost.

Just as Inco's Precision Casting Foundry found an inexpensive way to make the gimbal parts for gyros, so they may be able to cut your costs on complex small parts.

Whenever you have a part which is 6 inches x 5 inches or smaller, weighs under 3 lbs., requires starting tolerances as close as plus or minus .005 inch per linear inch, and needs 5 or more fabrication steps, there is a good chance you can cut costs by having it precision cast.

When you get precision castings from Inco in practically any metal from plain carbon steel to the new super alloys, you get many advantages.

Precision castings may save as much as 60 per cent of production costs. Make possible the use of extremely hard metals. Reduce machine shop bottlenecks. Lead to economies through re-design. Reduce metal scrap. Often permit the use of a higher alloy which otherwise would be too costly. Even make possible designs you previously thought impractical to produce.

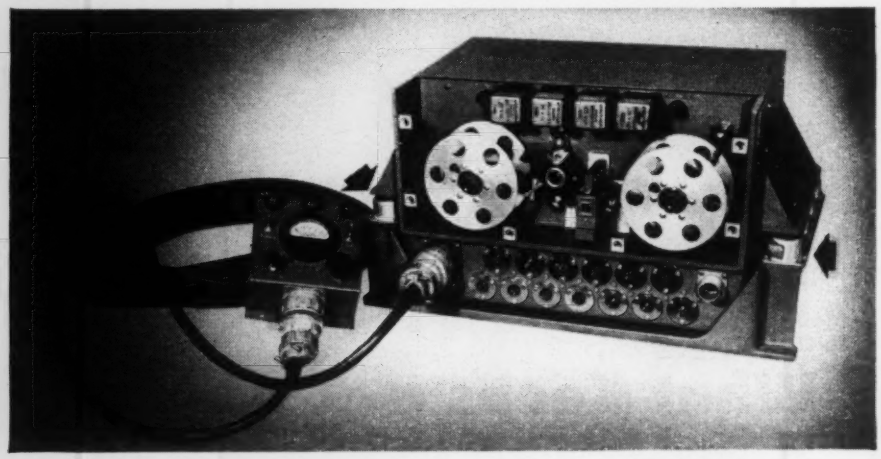
For more information, write for a free copy of "A Machinist's Nightmare Becomes a Designer's Dream."

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

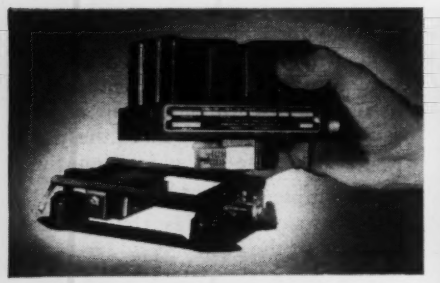
Inco Castings INCO TRADE MARK *PRECISION, SAND, CENTRIFUGAL*

SHOCK – VIBRATION – NOISE

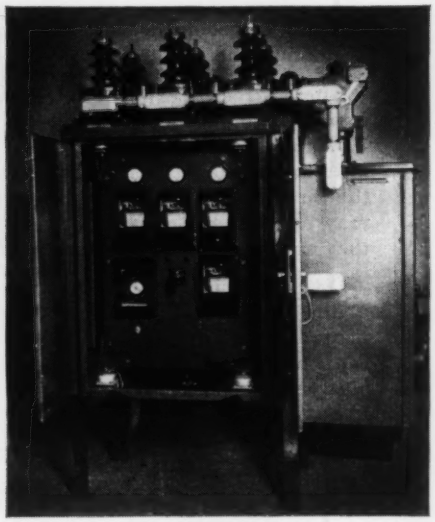
ISOLATION NOTES

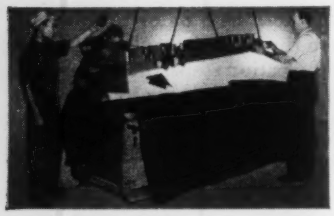


UNDISTORTED FLIGHT DATA are recorded by this Davies Laboratories aircraft data recorder. Tubes, relays, and recorder mechanism are protected against vibration by air-damped BARRYMOUNTS.



70% SIZE REDUCTION and 50% weight reduction, with no loss in performance, is achieved in this Minneapolis-Honeywell aircraft-fuel-gage power unit. Miniaturized air-damped BARRYMOUNTS helped make this saving possible, in protecting the reliability of the unit from vibrations and shock.





SENSITIVE ADJUSTMENTS ARE HELD when instrument and control panels are mounted on BARRYMOUNTS. Vibration from nearby heavy machinery cannot shake equipment out of calibration. Result: insured reliability of equipment and service.

NO SHIPPING DAMAGE, plus simplified packing, is Philco's experience with BARRYMOUNTS built into the packaging of microwave equipment. Pre-assembled equipments, with tubes and crystals in place, are shipped all over the world without damage, thanks to this modern packaging method. Write us for details.

The wide range of Barry products and the experience of Barry engineers can help you solve shock, vibration, and noise problems in any area of military or industrial activity. Call our nearby sales representative or write directly to us.

THE **BARRY** CORP.

722 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

Atlanta Baltimore Chicago Cleveland Dallas Dayton Detroit Los Angeles Minneapolis New York Philadelphia Phoenix Rochester St. Louis San Francisco Seattle Toronto Washington

Stress Relief

THE automatic factory is frequently discussed these days. Gene Murphy here takes a view of things to come in this technological area and points out some things to be kept in mind. Of course, any similarity between the capitalized terms that follow and any actual machines or systems is purely coincidental.

The Erskine Glotz Report

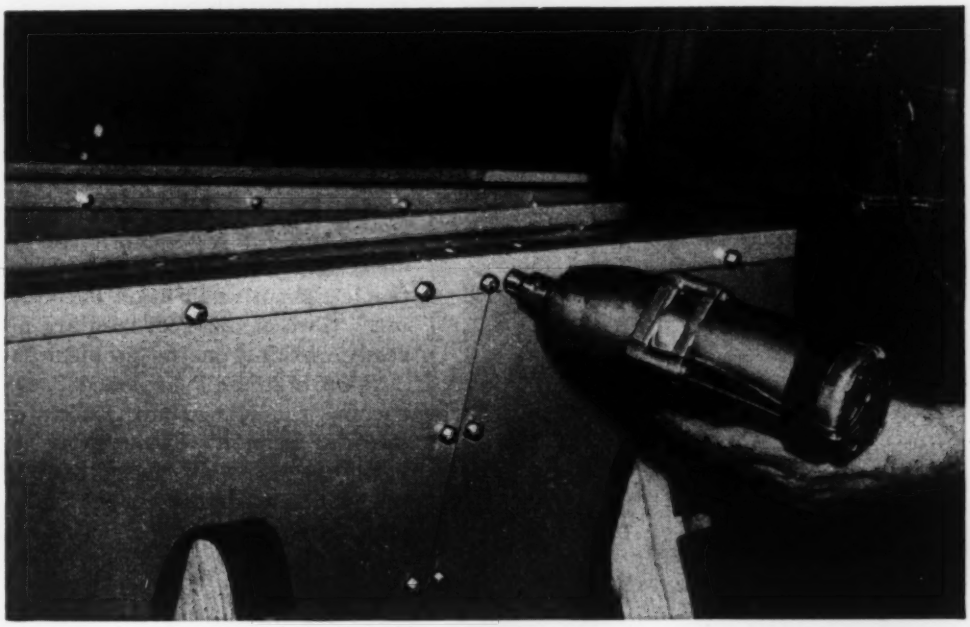
J. Q. Farnswether, President of Condensed Banquets Inc., was unhappy. It was a balmy March afternoon in the year 2052, and he should have been happy, but he wasn't. The Viewgraph on one corner of his desk indicated a drop of 2½-million units an hour in the plant's scheduled hourly output of 4-million Eight-Course Banquet Pills. Worse yet, the Inspectograph, on another corner of the desk showed that, of every thousand units produced, 75 lacked three or more of the required eight courses, and were being shunted automatically to the "seconds" or Cafeteria Sales Shipping Department.

To add to his unhappiness, J. Q. knew that Condensed Banquets' 15 directors, scattered in cities throughout the nation, also had Viewgraphs and Inspectographs. He knew, too, that unless things were put right in short order, 15 Thought-O-Grams would, at any minute now, be received by the plant's Automatic Electronic Computographic Personnel Handler, which would forthwith prepare and issue his severance papers (original plus 96 copies).

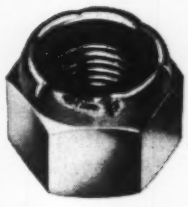
Setting the dial on his Thought Transmitter to "B. M. Hofsnagle, Plant Manager," he flipped the switch and thought, "B. M.—Get the hell in here!"

Three seconds later the Plant Manager panel in the gleaming metallic wall of the president's office whispered up and out of the way and B. M. glided noiselessly

To cut assembly time

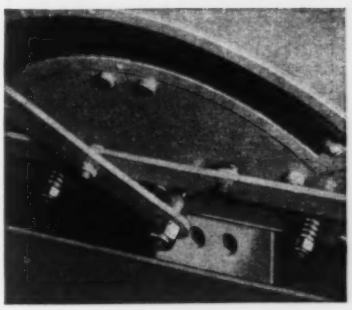


The one-piece, self-locking ELASTIC STOP nut is installed in seconds with an electric torque wrench. It will lock in any desired position on a bolt or stud—without extra parts or extra operations. Integral locking collars of nylon or fiber permit multiple re-use and re-setting.



and maintain adjustments

This Master Control mechanism on the Century Seeder must maintain a precise adjustment under conditions of severe vibration, in order to give a uniform seeding rate. ELASTIC STOP nuts maintain this accurate adjustment in spite of vibration, impact or stress reversal.



Century Engineering Corporation uses

Elastic Stop® nuts

H. H. McLeland, Chief Engineer for the Farm Equipment Division of the Century Engineering Corporation says:

"We specified Elastic Stop nuts on our new Century Seeder for all critical points because they withstood hundreds of hours of testing without losing their adjustment under vibration. They did not damage the bolt or stud threads, and could be re-set many times.

"We specified the same nuts for non-critical points because they facilitated rapid assembly with an electric torque wrench, and eliminated a lock washer. These features saved many hours of assembly time per day."

ELASTIC STOP NUT CORPORATION OF AMERICA

Mail coupon for design information

Elastic Stop Nut Corporation of America
Dept. N43-114, 2330 Vauxhall Road, Union, N. J.

Please send the following free fastening information:

☐ Elastic Stop nut bulletin
☐ Pointers on how to use them
☐ Here is a drawing of our product. What fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone____ State_____

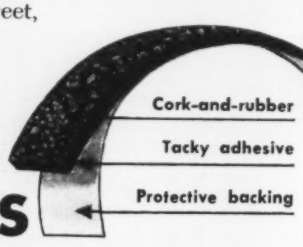
This cork-and-rubber tape stops auto fender squeaks

To eliminate fender squeaks and rattles, this auto manufacturer puts a strip of Armstrong's DK-153 Cork-and-Rubber Tape between the rear fender and the splash pan.

Held firmly in place by its own pressure-sensitive adhesive, DK-153 does more than just prevent contact between the two metal surfaces. The tape's high-friction surface, dotted with cork particles, actually snubs the sliding itself.

DK-153 Tape has hundreds of other uses. It protects finely machined or breakable parts from shipping damage, keeps telephones and furniture from skidding on polished surfaces, keeps water out of bus windows and parking meters, among other things.

You can get Armstrong's DK-153 Tape in many different widths and thicknesses, in sheets, rolls, ribbons, and die-cut shapes. For samples, write on your letterhead to Armstrong Cork Company, Industrial Division, 7311 Dean Street, Lancaster, Penna. Available for export.



ARMSTRONG'S DK-153 TAPE

Stress Relief

into the office in his Exectronic Nuclear Powered Chair.

J. Q. pointed to a brilliant red light flashing on the Viewgraph panel. "Look at that!" he roared. "In another hour, good old Condensed Banquets will be the laughly stock of the Automatic Factory Society!"

"I know," muttered B. M., nervously fingering his portable Electronic Executive Position Preselector. "Two of our best men are already working on the problem."

"Two of them!" exploded J. Q., causing the Fuse Blown indicator on his Thought Transmitter to light up. "I want every man in the plant on top of this job! Put all *three* of them on it!"

"But J. Q., we always keep one-third of our men in reserve in case the Digitalistic Computronic Section has one of its nervous spells."

J. Q. pointed tremblingly to a flickering amber light on his Company Director Attitude Meter. "See that," he said. "Twenty seconds after the red light comes on, you and I are unemployed—finis—kaput! Get *all three* of your men on the job!"

After B. M. had disappeared down the Plant Manager's Chute. J. Q. tossed down three double-scotch-and-soda tablets, and turned off his Thought Transmitter. "Oh, for the good old push-button factory of the past!" he thought.

In his office at the main plant of Electronic Digitalistic Computronic Controls sat Dr. Erskine Glotz, Ph.D., M.E. (Master of Electronics), EDCC's best serviceman. He was chuckling over the pages of an *Amazing Science* magazine left him by his great-grandfather when a red light (State of Critical Emergency) flashed on the annunciator above the Condensed Banquets name. His chair tilted him into a molybtanium chute that deposited him in his rocket cruiser, and in six seconds he was at Condensed Banquets.

A quick check of the equipment revealed that the Simplex-Servo Nonlinear Derivative Computer that gathered the ingredients necessary for each pill was in a state of mild shock. It was selecting

ingredients at random and making not the slightest attempt to check them before passing them on to the Sinusoidally Actuated Closed Loop Proportiomatic Compounding and Packaging Unit. Yet, strangely enough, all of the machine's transistors, relays, and components proved to be in order.

Repeated test problems fed into the machine confirmed Glotz' diagnosis of a psychosomatic rather than an electronic defect. For example, a simple problem involving integral calculus, physical chemistry, and basic geophysics caused the machine to shudder perceptibly and kick out its main circuit breaker. An extremely basic problem, usually easily solved by the Portable Junior Model Computronic, brought forth a solution that proved to be identical to J. Q. Farnswether's income tax.

Suspecting in advance what his findings would be Glotz proceeded to get to the root of the trouble. He reduced the temperature of the air-conditioned room housing the computer to a low level, thereby lowering the molecular activity within the unit and slowing up the frenzied oscillations of its complex electronic nervous system. A mild sedative was administered in the form of sinusoidally induced ultrasonic tin-tinnabulations, and the frantic chatter of relays fell off to an occasional calm click.

A number of questions, compiled by a renowned Viennese psychiatrist, were fed into the machine, and the answers were carefully analyzed. The original diagnosis had been correct. The unit was in the throes of an incurable nervous breakdown.

The cause? Glotz knew the answer, for this was the sixth of his company's machines in two years to suffer from the same disorder, and each breakdown had been during the month of March. In order to accomplish the exceedingly complex tasks assigned to them, these units had all been tuned to ultra peak sensitivity. Unfortunately, under these conditions, their quasi biphasal metatronic sensing circuits could not avoid intercepting and attempting

(*Concluded on Page* 258)

TWO MILLION WITHOUT A FAILURE!

parts: small connecting rods

alloy: "600" series metal, a high strength bearing bronze that contains no tin

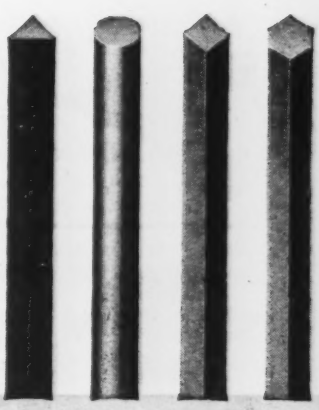
quantity to date: over 2,000,000

number of failures: none

forged by: Mueller Brass Co.

advantages: no bearing insert is necessary on either the wrist pin or crankshaft end because each rod acts as its own bearing. Dense homogeneous grain structure, close dimensional tolerances and high mechanical properties often permit redesigning for weight savings as high as 15% to 25%. "600" alloys have low coefficient of friction, high resistance to corrosion and tensile strength 2½ times greater than cast phosphor bronzes.

uses: compressors, outboard motors, small high speed gasoline engines. Best results are obtained if they operate against hardened, ground and polished shafts.



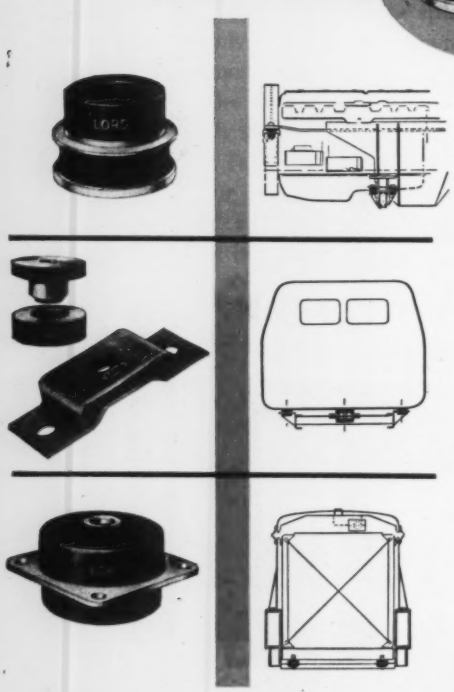
"600" SERIES ROD is produced in standard 12-ft. mill lengths and a wide range of sizes and special shapes. This rod has a fine, uniform grain structure and the mechanical properties are rigidly controlled in the cold drawing process. Scrap loss is greatly reduced in machining operations because of the complete absence of defects. For complete information, write us today.

104

MUELLER BRASS CO.

PORT HURON 15, MICHIGAN

LORD Bonded-Rubber Mountings... As Rugged As This



The world's largest "off-the-road" truck, Model 60 Dart, hauls 60 tons of copper ore from the huge shovels in the pits of The Bagdad Copper Mines of Bagdad, Arizona to the mine rim over tortuous, twisting, climbing roadways impossible for any other means of transportation. Contributing to the desired performance of this mammoth vehicle, Lord Bonded-Rubber Mountings cushion the twin radiators against vibration and shock, thus protecting the vital cooling system and reducing maintenance costs.

The two 350 hp. diesel engines and transmission assemblies are protected from the shocks of rough going by Lord Mountings . . . these same mountings provide a barrier between damaging engine vibration and the truck itself. To complete the job Lord Mountings protect the cab.

As rugged as the products they protect, Lord Bonded-Rubber Parts are used every day to improve the performance of industrial products large and small . . . Let us work with you.

BURBANK, CALIFORNIA 233 South Third Street
DALLAS, TEXAS 413 Fidelity Union Life Building
PHILADELPHIA 7, PENNSYLVANIA 725 Widener Building
DAYTON 2, OHIO 410 West First Street
DETROIT 2, MICHIGAN 311 Curtis Building
NEW YORK 16, NEW YORK 280 Madison Avenue
CHICAGO 11, ILLINOIS 520 N. Michigan Ave.
CLEVELAND 15, OHIO Room 811 Hanna Building

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

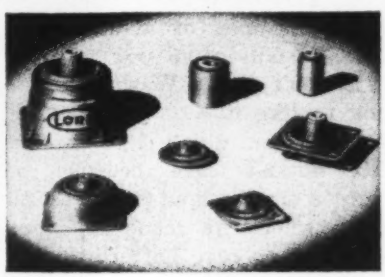
Headquarters for **VIBRATION CONTROL**

(Advertisement)

Lord Vibration Control Mountings . . . The Most Effective Protection For Electronic Equipment

In the rapidly advancing field of electronics, the control of destructive vibration and isolation of damaging shock are prime factors in the consideration of design engineers. Lord, Headquarters for Vibration Control, is constantly working with electronics engineers to improve the methods for protecting sensitive mechanisms.

For instance, Varo Static Converters which change alternating to direct current for aircraft with less than 1% voltage ripple are protected against shock and vibration by Lord Mountings. High fidelity Audio frequency electronic equipment such as Collins Radio Company manufactures is protected from vibration and shock through the use of Lord Mountings. The 212A-1 Broadcast Station Speech Input Console by Collins requires 28 Lord square Plate Form Mountings to protect each amplifier stage individually. This prevents mechanical interaction between stages and lessens acoustical feed-back effects.



Again the Agnew Spark Plug Welder by Agnew Electric Company uses Lord Mountings to support the electronic weld timers to prolong the useful service life of Mercury Vapor Tubes.

Lord Mountings, which you see illustrated in the accompanying advertisement, are used in a wide diversity of applications to protect electronic equipment and sensitive instruments. Business machines and such sensitive mechanisms, the accuracy of which must be perfect, are improved in operation and protected from damaging vibration and shock by Lord Mountings.

The Lord Manufacturing Company, Erie, Pa., offers a vast reservoir of recorded experience in the solution of vibration and shock problems. Your request for help on your own problem is welcomed.

SENSITIVE electronic equipment for airline transmitting and receiving must give continuously accurate results. For instance, note this "inside" view of the Collins Transceiver, mounted on Lord Temproof Mountings which isolate it from vibration and shock. Lord Temproof Mountings function efficiently throughout operational ranges of temperature from —80° to +250°F. The Collins Transceiver with automatically tuned elements for maximum flexibility and high power output delivers maximum performance in any weather, completely protected from vibration, shock and excessive equipment motion at resonant frequencies by Lord Temproof Mountings.

May we give you further details on this Lord application or help you solve your specific mounting requirement?

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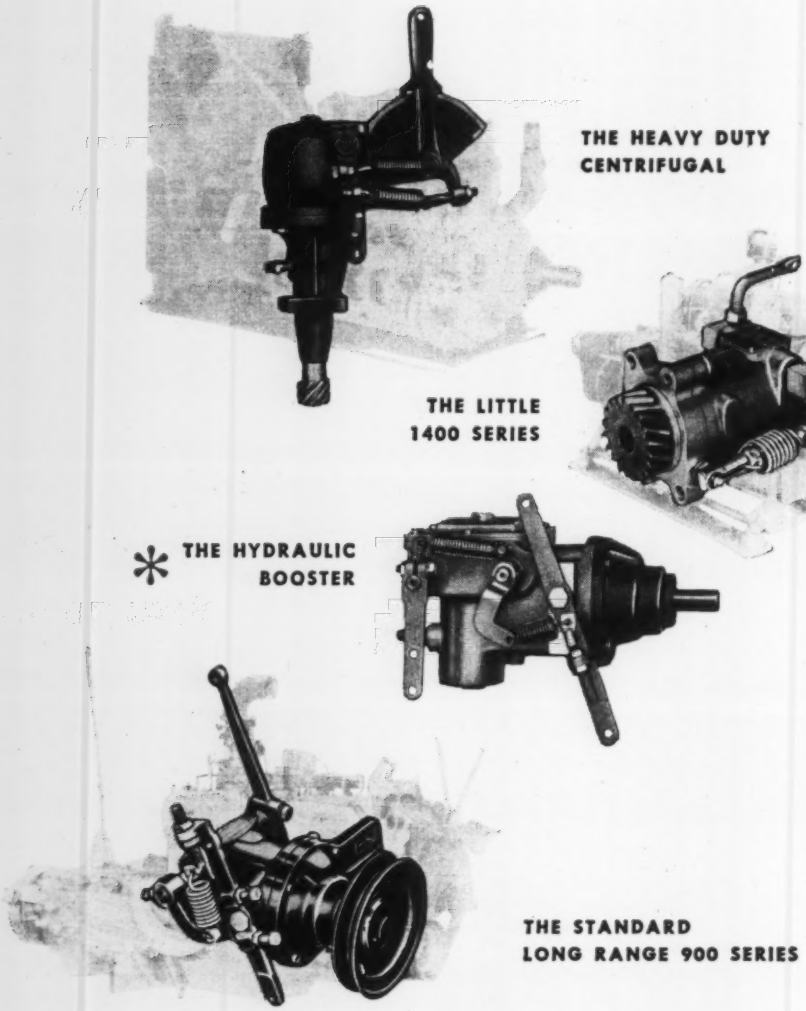
DETROIT 2, MICHIGAN	**NEW YORK 16, NEW YORK**	**CHICAGO 11, ILLINOIS**	**CLEVELAND 15, OHIO**
311 Curtis Building	280 Madison Avenue	520 N. Michigan Ave.	Room 811 Hanna Building

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

Headquarters for
VIBRATION CONTROL



PIERCE
GOVERNORS

preferred for gas (LGP), gasoline and diesel industrial engines . . . big, medium and small

Pierce centrifugal governors are your most dependable and efficient control mechanisms for industrial engines . . . from small generator sets to monster power units . . . gas (LPG), gasoline or diesel. For engines requiring extra power to position fuel rack or valve, the Pierce centrifugal with hydraulic booster* (for original equipment only) is ideal! Pierce offers a ready solution to most engine governing problems . . . send full details and specifications on your particular problem.

THE PIERCE GOVERNOR CO., INC.
1606 OHIO AVENUE, ANDERSON, INDIANA
"World's Most Experienced Governor Manufacturer"

PIERCE — THE MARK OF QUALITY

Stress Relief

to solve the mental problems of any strong-minded individual within a radius of 2000 yards. In all of the breakdowns that had occurred so far, the pattern was the same. Presidents, and in some cases even vice presidents of the companies concerned had been giving considerable thought to the problem of their income taxes. The computers had unavoidably intercepted these thoughts, and, by straining every electron in attempts to arrive at satisfactory solutions, had been reduced to states of gibbering electronic idiocy.

"The best and most obvious solution," said Glotz, reporting to EDCC's president, "is at the same time simple, yet impossible,—a sizable reduction in the income tax rate. Since this is impossible, we have but one alternative, to greatly reduce the sensitivity of our machines. This will lower their efficiency which will in turn reduce plant production and product quality. Plant profits will decrease, and along with them, the taxable incomes of their executives. It will solve our problem but I don't think Washington is going to like it."

Washington didn't like it, but Glotz doesn't care because he bought a small island in the South Pacific where he leads a happy life collecting rare butterflies.

They Say . . .

"The worst thief of time, among a man's associates and his bosses is the fellow who takes twenty minutes of rambling discourse to tell what could be said in twenty words. There is a curious and widespread tendency among engineers to surround the answer to a simple question with so many preliminaries and commentaries that the answer itself can hardly be discerned in the verbal fog. It is so difficult to get a direct answer out of some men that their usefulness is thereby greatly diminished. The tendency is to explain the answer before answering the question."—LEWIS A. VINCENT, *general manager, National Board of Fire Underwriters*

Meetings and Expositions

29 West 39th St., New York 18, N. Y.

Jan. 18-22—

American Institute of Electrical Engineers. Winter general meeting to be held at the Statler Hotel, New York, N. Y. Additional information may be obtained from society headquarters, 33 West 39th St., New York 18, N. Y.

Jan. 22—

Malleable Founders' Society. General society meeting to be held at Hotel Cleveland, Cleveland, O. Additional information may be obtained from society headquarters, 1800 Union Commerce Bldg., Cleveland, O.

Jan. 25-27—

Plant Maintenance & Engineering Conference to be held at the Hotel Conrad Hilton, Chicago, Ill. Additional information may be obtained from the exposition management, Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 27-29—

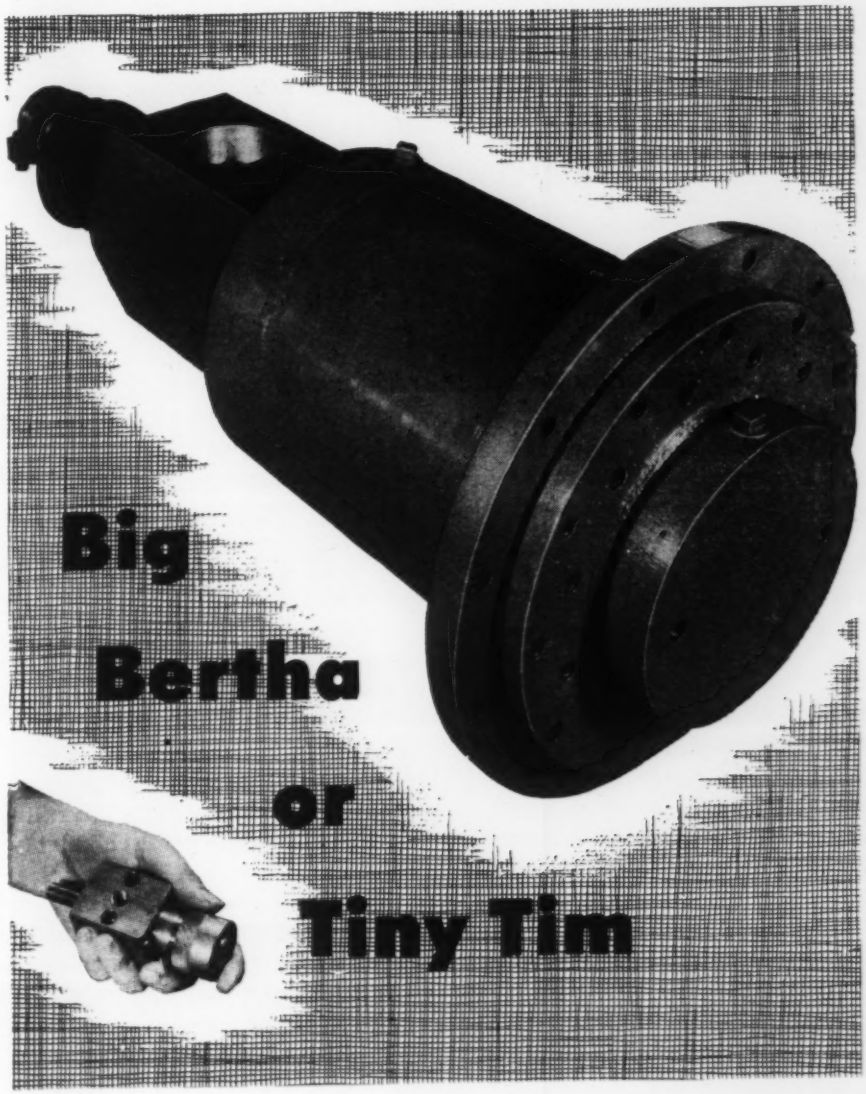
Society of Plastics Engineers. Tenth annual technical conference to be held at the Royal York Hotel, Toronto, Ontario, Canada. Additional information may be obtained from society headquarters, 513 Security Bank Bldg., Athens, O.

Feb. 3-5—

Society of Plastics Industry. Ninth annual reinforced plastics division conference to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 67 West 44th St., New York 18, N. Y.

Feb. 15-17—

American Management Association. Personnel conference to be held at the Palmer House, Chicago, Ill. Additional information may be obtained from society headquarters, 330 West 42nd St., New York 18, N. Y.



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DESIGNING Scales and Charts

. . . for easy and accurate reading

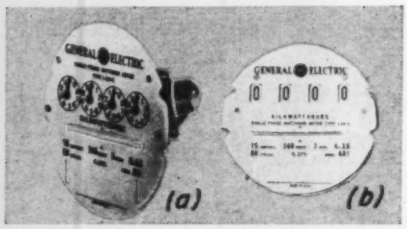
DESIGN ABSTRACTS

By J. G. Fleming
Research Engineer
Bristol Co.
Waterbury, Conn.

MAN becomes an important consideration in the design of apparatus when it is man-operated. World War II brought the design engineers and the psychologists together as a team, to work out their related problems. In many cases, it was found necessary to redesign devices to make for more accurate operation by the average man rather than to depend on a highly trained operator.

Perhaps one of the most unreadable instruments is the watthour meter which keeps tabs on the consumer's power use. The accumulating character of this instrument minimized the importance of mistakes; but when consumers were asked to read their own meters during World War II, this consideration was hardly adequate. In *Fig.* 1 is shown a new improved watthour meter which is compared to the previous design.

Fig. 1—Reading errors of watthour meter design, *a*, were eliminated with redesigned meter, *b*



Mr. H. H. Johnson, of Consolidated Edison of New York, includes readability as one of the six major considerations in power plant instrumentation. Furthermore he says, "The use of models, either full size or miniature, represents subconscious attempts at applying human engineering principles to grouping and placing of instruments." This is typical of the attitude of a great many instrument men in the power plant field.

Power plants have numerous processes which are completely automatic. Similarly, the high speed operations in many other industrial operations finds man too slow; only automatic equipment is satisfac-

Fig. 2—Indicating temperature controller scale, *a*, gave impression of instrument instability because of numerous reading errors. Redesign, *b*, corrected this by simplifying reading

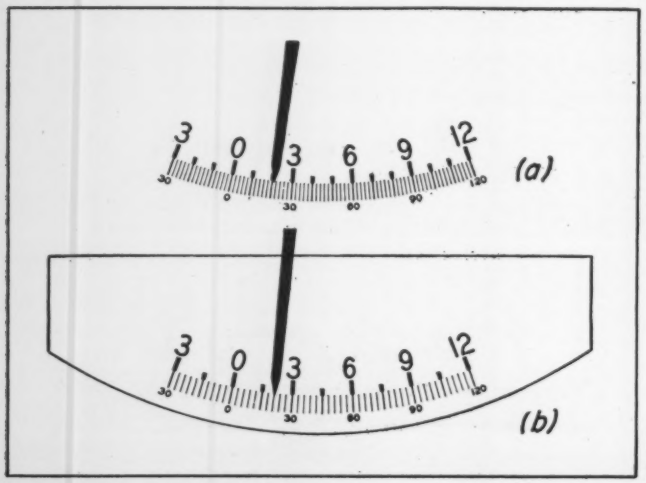
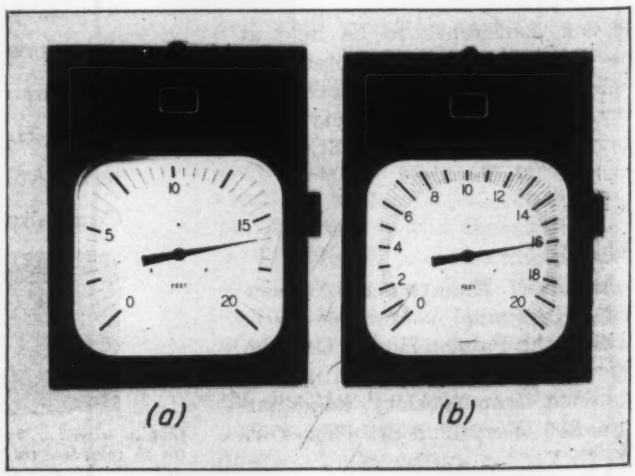


Fig. 3—Scale on liquid level indicator, *a*, caused reading errors due to emphasizing marks at 2.5, 7.5, etc. Instrument range was redesigned, *b*, to help prevent reading errors



tory. However, complete automatic control is expensive and in many cases is not economically justifiable. Today, and for many years to come most industrial plants will be man-operated.

Instruments serve as the communication means between a process and an operator. Instruments can motivate corrective action and communicate all pertinent information to a central control room. Instrumentation is the nervous system of modern industry.

As the responsibilities of the operator are increased, these questions arise, "Is it possible for him to perform his tasks efficiently? In time of emergency can he make all the readings accurately and quickly?"

For example, a temperature controller operates in connection with a process in which dependability is critical. The variable is measured at the process and then transmitted to a central control room. The instrument scale is similar to that shown in *Fig.* 2*a* with major markings at multiples of 30, and smallest markings valued at 3. A cautious user sets up a regular instrument accuracy inspection for this critical measurement. In an actual case, calibration checks made with values like 21 were frequently misread, whereas marked values like 30, etc., showed a minimum of reading error. This resulted in the belief that the instrument was unstable because calibration required frequent adjustment.

The scale was redesigned as shown in *Fig.* 2*b*. The latter has major markings at 30, emphasized markings at multiples of 10 and smallest division markings in 2's. This instrument scale is much easier to read through the entire range. Errors are reduced, and the operator thinks instrument is more stable.

Fig. 4—Scale having divisions that are nearly impossible to read even by an experienced operator

An instrument is required to measure the liquid level in a drum. The range covers 0 to 20 feet. An accuracy of 0.5 per cent or ±0.1-foot is desired. The scale on the instrument shown in *Fig.* 3*a* has numbered emphasized marked values of 0, 5, 10, 15, 20. Then 2.5, 7.5 etc., are emphasized, and the smallest marked division is 0.5. Frequently, in this case, a value such as 16 feet is read as 17 feet, representing an error of 1 foot or a 5 per cent error.

When the instrument range was redesigned as shown in *Fig.* 3*b*, it appears to be relatively free of major reading-error possibilities. The scale is no longer the limiting factor of an instrument with ±0.5 per cent accuracy specification. This is accomplished by numbered emphasized marked values of 1's and smallest marked values of 0.5's.

Scales have been designed that are nearly impossible to read whether the operator is skilled or not. An example of such a scale is shown in *Fig.* 4. What is the indicated value?

The Pennsylvania Electric Association has made a thorough study of the problem of the operator observing instrument scales and charts. They have investigated instrument room lighting and have helped develop new instrument fronts for electrical switch-gear indicators where instrument case shadow was removed.

Preferred Scale Divisions: Carefully conducted experiments by psychologists have shown that the order of preference of scale division for least reading error is 1-2-5. The reading error in the best case may be less than one-fourth that of the worst case.

Scale marking subdivisions which have proved successful are:

1. Numbered emphasized marked values.
2. Unnumbered emphasized marked values.
3. Unnumbered, unemphasized marked values.

Emphasis is made by variation of line weight in thickness.

Scales Read at Two Distances: Industrial instruments often require readable measure at a distance of 15 to 30 feet. They may also need to provide accurate readings when the operator is within 1 to 5 feet of the instrument. This dual requirement has to be accomplished with a minimum of interference of one function on the other.

Examples of improvement in this regard are shown in *Fig.* 5. A pneumatic indicator is shown in

Fig. 5—Pneumatic indicator, *a*, was improved in design, *b*, for close and distant reading. Final redesign, *c*, provided even greater improvements in readability

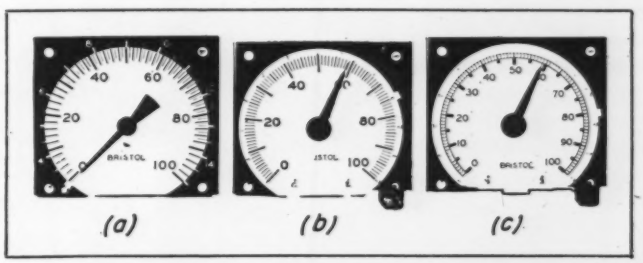


Fig. 6 — Pressure indicating scale, *a*, was redesigned, *b*, for easy distant reading. Additionally a finely divided scale is provided for reading more accurately at close range

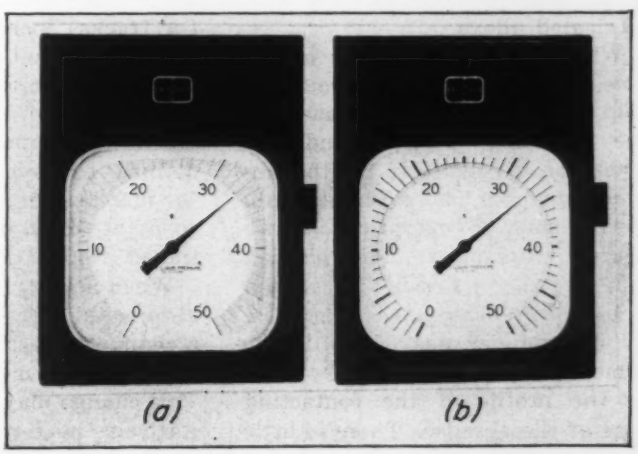


Fig. 5*a* before redesign. The first redesign is shown in *Fig.* 5*b* which provides a definite improvement in readability. Final redesign, *Fig.* 5*c*, really made this indicator easy to read.

In another case a scale is shown in *Fig.* 6*a* before it was redesigned. *Fig.* 6*b* shows the scale after redesign. Numbered emphasized intervals are multiples of 10, unnumbered emphasized intervals of 5's and unnumbered, unemphasized intervals of 1's. This scale can be readily read from a distance and it complements the calibration scale subdivided in 0.2's for easy reading at close range.

Readability of Type: In general, the designer of type selects his characters on the basis of obtaining a maximum blending of characters such as shown in *Fig.* 7*a* so that the reader is quickly able to select words. This has proved to be very satisfactory for newspapers and books. However, in the case of numbers on instrument scales, dials and charts, engineering psychologists have found the use of a special type shown in *Fig.* 7*b* reduces reading error by as much as 50 per cent. The feature of this type is the characteristic which makes the 8's and 9's along with the 5's and 6's very distinctive; therefore chances of misreading these numbers are minimized.

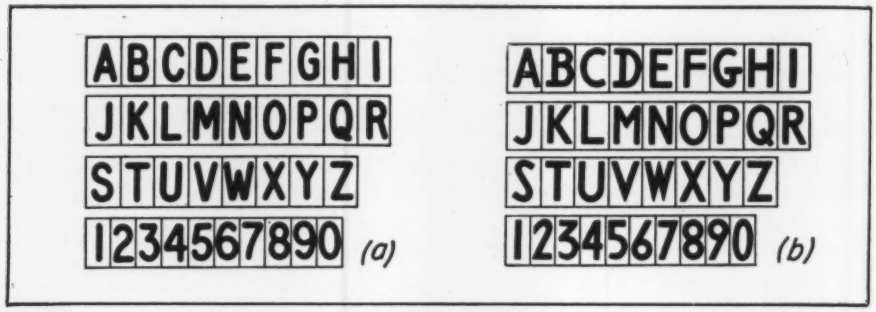


Fig. 7—Type commonly employed on scales, *a*, when redesigned, *b*, reduced reading errors 50 per cent

From a paper entitled "Human Engineering in Power Plant Instrumentation" presented at the ISA National Conference in Chicago, Ill., September, 1953.

Analyzing Metal Wear

By Harry Czyzewski

Technical Director
Metallurgical Engineers Inc.
Portland, Oreg.

ALLOYS of the class called "self-lubricated" alloys, have a resistance to accelerated mechanical abrasion which it has not been possible to duplicate by external lubrication. Alloys in this class include gray cast iron (graphite lubricant) and leaded copper-base and iron-base alloys (lead lubricant). Mechanical analysis can explain the failure of externally lubricated alloys to equal the performance of self-lubricated alloys.

When a particle abrades a surface, there is a definite relationship between the dimensions of the abrading particle and the track, or furrow, left on the abraded surface. The mechanical abrasion may be classified in two general categories: (1) normal, and (2) accelerated. In normal mechanical abrasion, the track left by the abrader has a profile the same (except for elastic recovery) as the profile of the contacting part of the abrader. There is little difference in response to normal mechanical abrasion between self-lubricated and homogeneous (externally lubricated) alloys. In accelerated mechanical abrasion, the track left by the abrader has a larger profile than the profile of the contacting part of the abrader.

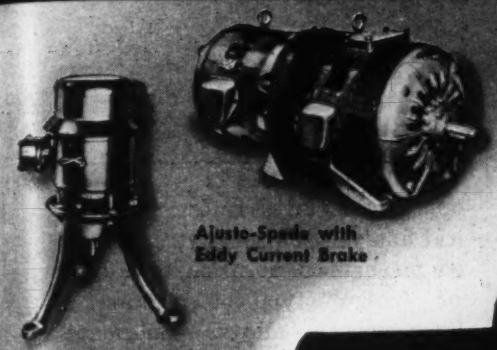
Seizing and Galling: Seizing is defined as the state in which the relative motion of opposing metal parts is stopped, because the track (or tracks) increases in profile to the extent that further propagation of the track requires more translational energy than is available in the system. Galling may be defined as arrested seizing; i.e., the increased track profile becomes constant or decreases with continued propagation of the track.

When seizing is initiated in metal-to-metal wear, it is evident that a change has occurred from normal to accelerated mechanical abrasion. This change may be analyzed qualitatively in terms of stress distribution at the point of contact being considered.

In metal-to-metal wear, the parts are in relative motion and the effect of a translational force component on the contact-pressure distribution must be evaluated. In effect the translational-force component causes higher shear stresses on the side of the point of contact opposite the translational force. Also, in metal-to-metal wear the contacting asperities (high spots) do not make point contacts, but actually make contact over a certain area.

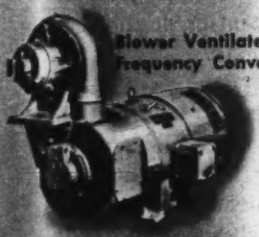
Also in the case of metal-to-metal wear, plastic deformation occurs. However, stress distribution for plastic deformation may be considered similar to that for elastic deformation, since metals used industrially in metal-to-metal wear applications are generally of the cubic-crystal systems, which have available many slip planes for plastic flow. Thus, as a first approximation the elastic modulus may be replaced by the work-hardening modulus in quantitative studies.

Normal Pressure: Galling and seizing are incurred with increase in normal pressure between the

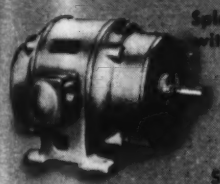


Ajusto-Speede with Eddy Current Brake

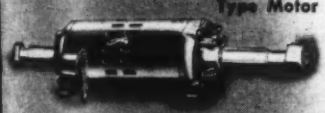
Single-Phase Pump Motor with Tripod Base



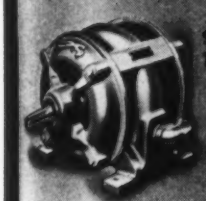
Blower Ventilated Frequency Converter



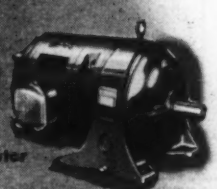
Splash-Proof Motor with Flange



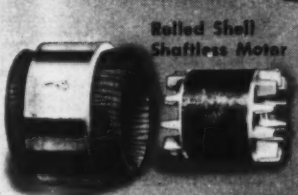
Special Arbor Type Motor



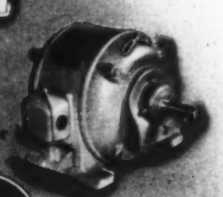
Self-Cleaning Textile Motor



Gearmotor



Rolled Shell Shaftless Motor



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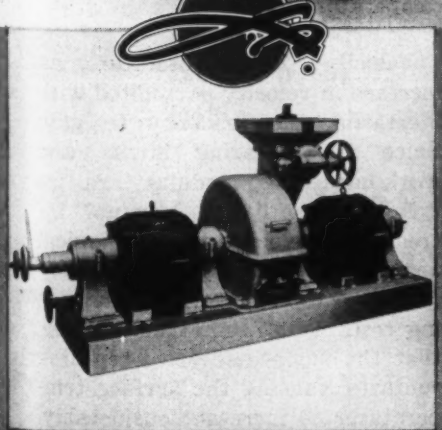
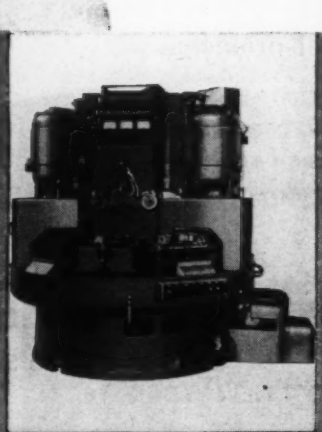
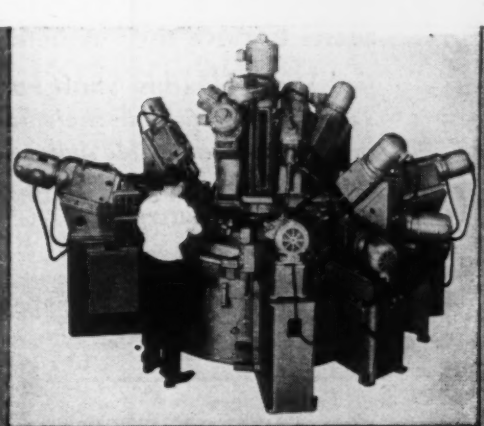


Two Louis Allis open, drip-proof, floor horizontal, shaftless attrition mill motors drive this double-runner attrition mill.



A Louis Allis frame-type, shaftless, squirrel-cage motor is built into the grinding heads of this vertical-spindle, rotary, automatic surface grinder.



Each of the sixteen heads of this automatic drilling and tapping machine has its own Louis Allis motor designed for the specific range and type of work handled by that particular head.

THE PROBLEM

TO PROVIDE A CONVENIENTLY OPERATED CONTROL

The designer of a cabinet type oil heater had to provide a manual control for an oil and air metering valve which was placed at the bottom of the unit. He wanted to place the control knob on the front of the heater where it could be easily seen and operated. To do this meant bringing the control linkage around a 90° turn. To solve the problem, he chose

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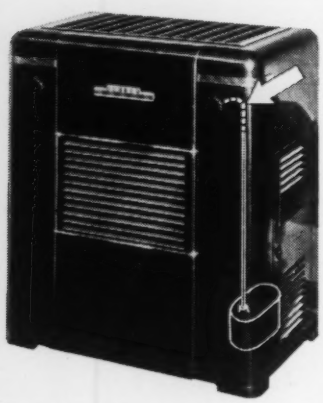

In this way he was able to connect the control dial to a rod running to the valve with a single part which did not require alignment and could be installed in a minimum amount of time. **The net result was impressive savings in assembly and manufacturing costs,** advantages that most designers gain when they use S.S.White flexible shafts to solve their remote control problems.

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DENTAL MFG. CO.
Dept. 4, 10 East 40th St.
NEW YORK 16, N. Y.

Western District Office • Times Building, Long Beach, California

Design Abstracts

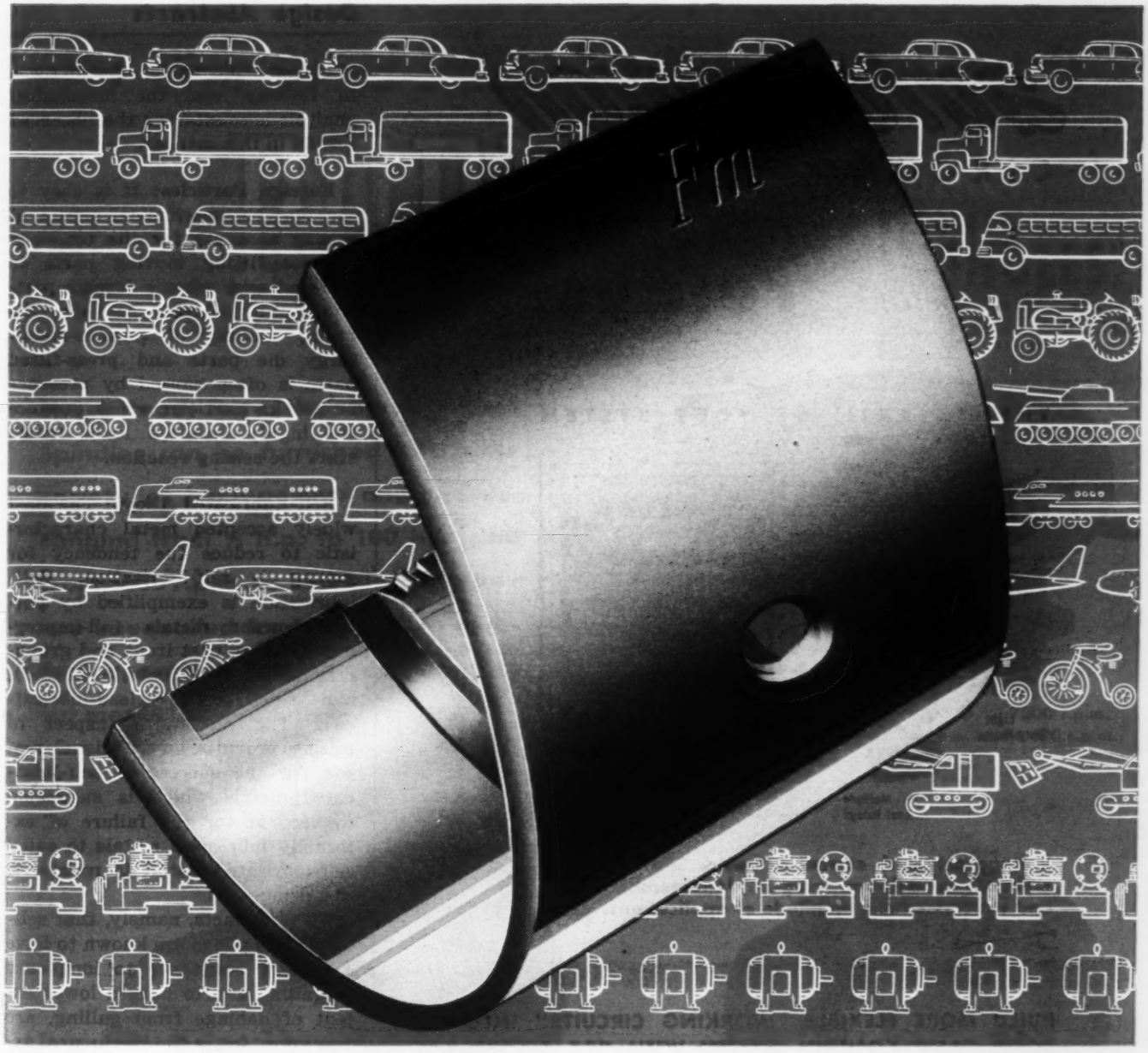
opposing metal surfaces. Mechanical analysis shows that accelerated mechanical abrasion is a "go" or "no-go" type of reaction in homogeneous alloys. Lubricants ordinarily alleviate the tendency to seize by separating opposing metal surfaces and preventing high local concentrations of load.

Surface Finish: Lubrication theory predicted that the separation of opposing metal surfaces would be accomplished more easily if the surface finish was improved; i.e., if all the asperities were removed. Now it is known that a high order of surface finish increases the tendency for galling and seizing. The mechanical analysis of accelerated mechanical abrasion indicates that a low-order surface roughness tends to gall because the amount of deformation that will cause instability is reduced so much.

Work-Hardening Modulus: It is known that the critical shearing stress for plastic deformation increases with strain; i.e., work-hardening occurs. The metal with highest work-hardening modulus, therefore, would be expected to have the greatest resistance to galling, all other factors being the same. In general, the softer alloys gall more readily than hard alloys.

Temperature: Tendencies to gall increase with a rise in temperature. This also is consistent with mechanical interpretation, since critical shearing stress and work-hardening modulus decrease as the temperature increases.

Velocity: In the literature, an increase in velocity is credited with increasing the tendency to gall. Since the shearing stress and work-hardening modulus are increased slightly by nominal increases in velocity, the mechanical analysis does not verify the observed relationship. However, galling tests usually are conducted so that the surfaces receive repeated contacts, causing the surface temperatures to increase considerably. The increase in temperature more



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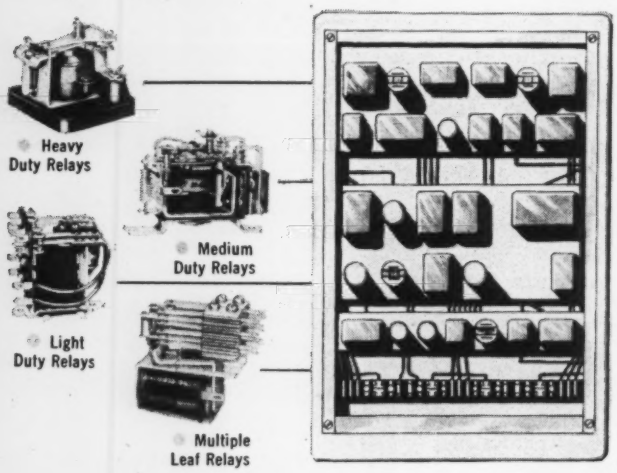

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Design Abstracts

than compensates for the increase in velocity, and the mechanical analysis accounts for the observed results in this manner.

Foreign Particles: It is easy to see that the mechanical aspect of seizing accounts for the tendency of close-fitting moving parts to gall and seize when a foreign particle is introduced between the parts. Galling of powder-metallurgy die parts and press-fitted parts is often caused by presence of foreign particles which produce the highly localized loads which start the seizing reaction.

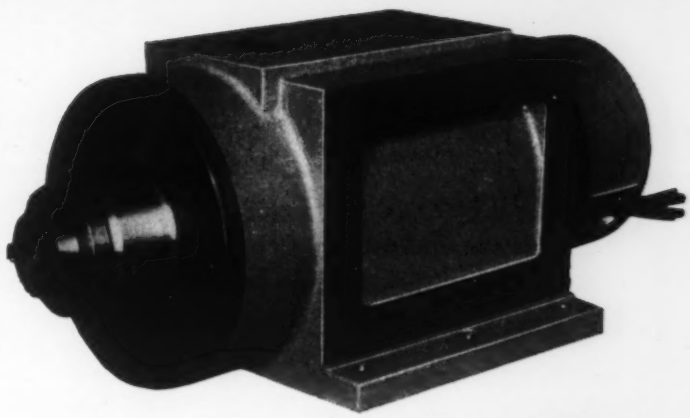
Self-Lubricated Alloys: The most widely accepted metal characteristic to reduce the tendency for galling is self-lubrication. Self-lubrication is exemplified by porous powder metals (oil-impregnated), gray cast irons and graphitic steels (graphite-lubricated), and leaded bronzes (lead-lubricated). The mechanical aspect of seizing provides an additional reason for the success of self-lubricated metals which is suggested to account for the failure of externally lubricated metals to equal self-lubricated metals in resistance to seizing.

The two facts, namely, that self-lubricated alloys are known to have a greater resistance to incipience of galling and to have a lower extent of damage from galling, are accounted for in the mechanical aspect of accelerated mechanical abrasion. On this basis, porous alloys without a lubricating agent would be expected to gall less than nonporous alloys, also unlubricated.

The mechanical interpretation of accelerated mechanical abrasion provides a principle upon which to design surfaces of "engineered roughness." It is evident that the roughness must be on a scale comparable with the asperity size; i.e., the microscopic scale. The importance of graphite-flake size, shape, and distribution in gray cast-iron applications is well known. From the standpoint of self-lubrication, the dimensions of the lubricant reservoir would not be too critical. Yet, in practice, the graphite-flake

Specify POPE HIGH FREQUENCY PRECISION SPINDLES

These Heavy Duty, High Speed Milling Spindles can be furnished in a wide variety of horsepowers and speeds, ranging from ½ h.p. to 100 h.p. and from 3600 r.p.m. to 60,000 r.p.m. They are unequalled for long life, trouble-free operation and rugged ability to cut metal fast.



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These Spindles are arranged to operate in horizontal, vertical or angular position, whichever you specify.

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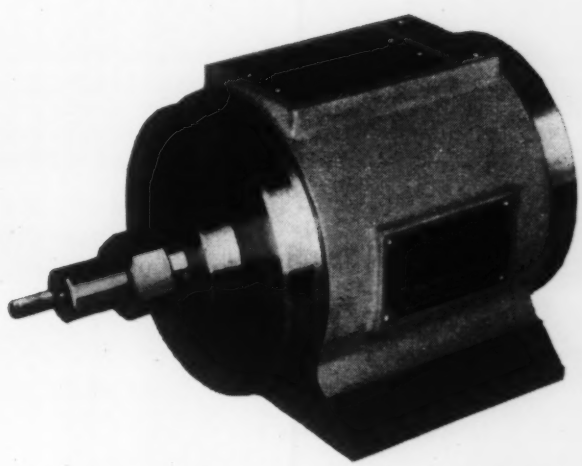

2 pole — 4 pole motor ¾ h.p. at 12000 r.p.m.
½ h.p. at 6000 r.p.m. 1 h.p. at 18000 r.p.m.
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Design Abstracts

classification is controlled closely for such parts as piston rings, cylinders and other wearing-surface applications.

A. M. Talbot and R. A. Kozlik have reported that gall resistance of ductile iron was comparable to flake gray iron. They found that for equal graphite contents and similar matrix structures, gall resistance of flake-graphite iron was superior to that of ductile iron. Ductile iron was equal in gall resistance to gray iron in which the flake-graphite content is lower than the nodular-graphite content.

Porous chromium-plated surfaces are superior to the nonporous surfaces in resistance to galling. Effects of size, shape, and distribution of porosity again were found to be more critical than would be predicted from lubrication theory, since channel porosity of chromium plate is superior to round-pit type porosity.

From a paper entitled "Mechanical Aspect of Seizing in Metal Wear" presented at the Semiannual Meeting of ASME in Los Angeles, Calif. in July, 1953.

Solid Lubricants

By W. E. Campbell

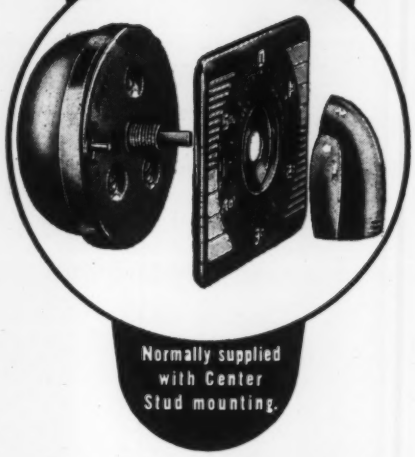
Bell Telephone Lab.
Murray Hill, N. J.

RAPID increase in the use of complex mechanisms in military applications has led to an increase in interest in solid lubricants. These mechanisms are frequently required to operate over an extremely wide temperature range—from 100 to 750° F. In many cases, mechanisms having inaccessible bearings may be stored for indefinitely long periods, and yet must function with split-second accuracy at a moment's notice. Under these circumstances dust collection and corrosion become important considerations in addition to that of lubricant stability.

A solid lubricant may be defined as a solid material interposed between two surfaces moving relative to each other to prevent direct contact and thus reduce fric-

Give your appliances this EXTRA VALUE ...at NO extra cost!

MARK-TIME two-speed BELL TIMER



Normally supplied with Center Stud mounting.

The exclusive, patented 2-speed feature of this Mark-Time unit makes it TWO timers in one! . . . and puts more "sell" into your appliances!

Here's why: in the long-time position, the user can measure time up to ONE HOUR for baking, roasting, stewing and other lengthy cooking operations . . . can use it as a reminder for appointments and other household jobs, too! By moving the lever to the short-time position, the user can obtain settings within seconds for boiling eggs, pressure cooking . . . precise timing for all short time jobs up to SIX MINUTES, where even fractions of a minute are important.

At the end of the pre-set time period, in either long or short range, this timer gives a clear, resonant bell signal.

Available with a wide variety of modern dials and knobs, also in 2-hour, 12-minute range.

Write today for full details and prices.

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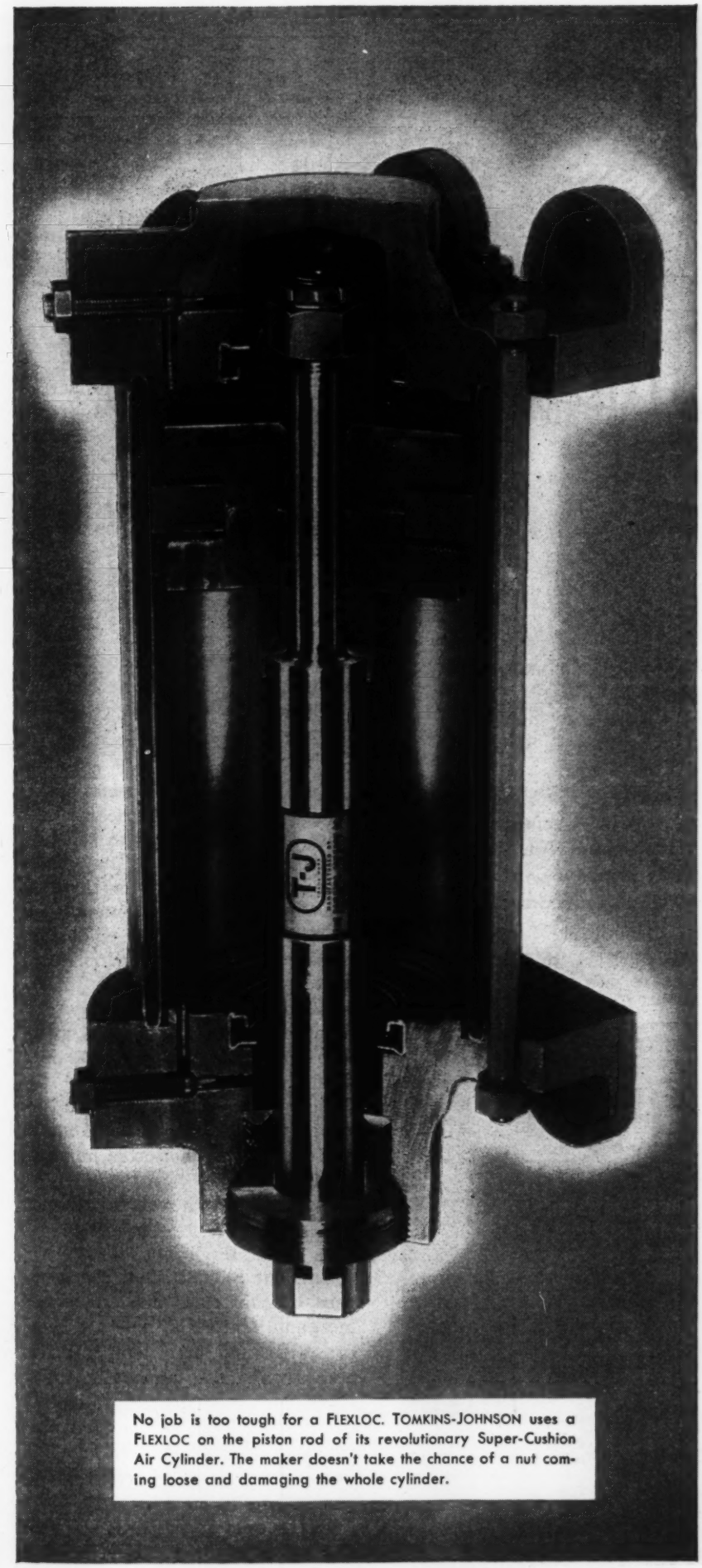

No job is too tough for a FLEXLOC. TOMKINS-JOHNSON uses a FLEXLOC on the piston rod of its revolutionary Super-Cushion Air Cylinder. The maker doesn't take the chance of a nut coming loose and damaging the whole cylinder.

What FLEXLOC locknuts do for you

FLEXLOCs eliminate complicated, time-consuming methods of locking threaded fasteners. They offer simpler, faster application and safer, more dependable locking than plain nuts and lockwashers, castellated nuts and cotter pins, or nuts and jam nuts. And they won't work loose.

The reasons for all this are plain. FLEXLOCs are one piece—nothing to assemble, come apart, lose or forget. FLEXLOCs are all metal—have higher tensile than most other locknuts and are not affected by temperatures to 550°F. FLEXLOCs are both stop and locknuts—don't have to seat to lock, and stay put anywhere on a threaded member as soon as their locking threads are fully engaged.

SPS can deliver any quantity of FLEXLOCs in a wide range of sizes. Stocks are carried by industrial distributors everywhere. Write for literature. SPS, Jenkintown 18, Pa.

FLEXLOC®

LOCKNUT DIVISION

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Our Fiftieth Year : A START FOR THE FUTURE

Carrying meats, vegetables and groceries past the cash register to the wrapping clerk, at 18 ft. per minute, check-stand conveyors send super market shoppers quickly on their way in Dillon's 25 Kansas food stores.

Depended on to turn each of the grocery-laden belts at correct speed is a Winsmith Speed Reducer, special assembly Model 2B, with a reduction ratio of 48:1. "...the only reducer which would fit in the limited space beneath the check-out counter and give proper operation," states J. S. Dillon and Sons Food Stores Co., Inc.

Compactness, coupled with ruggedness and dependability, have made Winsmith Speed Reducers essential components of numerous types and makes of essential equipment. Worm, helical and differential units are promptly available within the range of 1/100 to 85 hp in 1.1:1 to 50,000:1 reduction ratios.

Request catalog 148 for details.

WINSMITH, INC.
16 Elton St.
SPRINGVILLE (Erie County), N. Y.

MEMBER OF AGMA

Design Abstracts

tion and wear. To do this with maximum effectiveness, all sliding must be between layers of solid lubricant.

Properties: Desired wear and friction-reducing properties of a solid lubricant film are the following:

1. Low shear strength
2. Strong surface adherence
3. Good elastic properties
4. Continuity

In addition to these properties of the solid lubricant which directly influence its frictional behavior, there are several others which are of practical importance in choosing the type of film for a given function.

1. Thermal stability
2. Melting point
3. Electrical conductivity
4. Thermal conductivity
5. Chemical inertness
6. Corrosion prevention ability
7. Color
8. Density
9. Particle size and uniformity
10. Abrasive content

There is one important characteristic which solid lubricants as a class lack—the ability to self-heal breaks in the film. They function successfully only as long as the film remains continuous. It is important to design equipment employing solid film lubricants well within the life span of the lubricant. Unfortunately there is no standardized test method available for evaluating the life of a solid lubricant. Because of the rapidly increasing use of solid lubricant films, a standardized method for their evaluation is much to be desired.

Solid lubricants may be grouped into six classes.

Laminar Solids: Since the members of this class are almost all inorganic materials, most of them can withstand high temperatures, and several are unusually inert. Examples are graphite, molybdenum disulfide or molybdenite, tungsten disulfide, vermiculite, mica, boron nitride, borax and silver sulfate.

In the case of graphite, the ease of slip between adjacent crystal

DOWEL PINS

HOW TO USE THEM

1. Precision Dowel Pins are principally used where parts must be accurately positioned and held in absolute relation to one another whether stationary or in motion. They facilitate quick disassembly and completely accurate re-assembly.

2. Allen Dowel Pins are also used as plug gauges.

3. As plugs for determining angular dimensions of dovetail slides.

4. As hinge and wrist pins in applications requiring initial and permanent accuracy.

5. As accurate, economical roller bearings and axles.

6. As guide pins, stops and position locators.

HOW TO JUDGE THEM

1. *On precision, for low tolerance applications.* (Allen Dowel Pins are ground to a maximum microinch finish of 6 RMS protected by a rust preventive.)

2. *On strength, for shear resistance.* (Allen Dowel Pins are made from special Allenoy Steel, heat treated. Single shear strength measures from 160,000 to 180,000 psi.)

3. *On hardness of surface and a core hard enough to prevent "mushrooming" when driven into a tight hole.* (Allen Dowel Pins have a surface hardness of 62-64 Rockwell C Scale and core hardness of 52-54. Average case depth .010 to .020 depending on size.)

The simple sure way to be sure of uniformly superior dowel pin quality is the same as in buying precision socket screws — *get genuine Allens from your Industrial Distributor.* Only he sells them but *we will welcome your direct request for literature or application engineering assistance.*

ALLEN HEAD

ALLEN

Available in 108 Standard Sizes from ⅛" x ⅜" to 1" x 6". Standard tolerance .0002 oversize. Most sizes also standard in .001 oversize for repair work.

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You can achieve the sealing efficiency you want . . . eliminate specification problems . . . work unhampered from drawing board to production—when you work hand-in-hand with "John Crane's" experienced engineering staff and available facilities.

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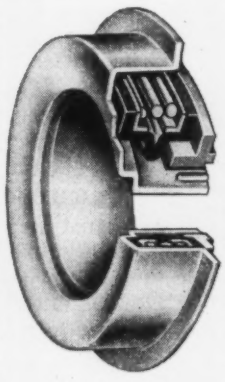
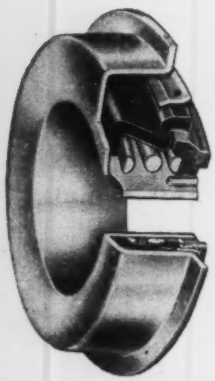


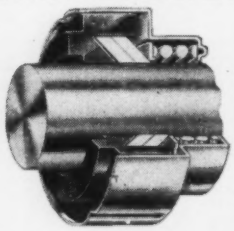
TYPE 6-A

Pressed-in packaged unit recommended for small shafts on hot or cold water, oil, gasoline or soapy liquids . . . pressures to 75 psi . . . temperatures from —65° F. to +220° F. Available in stainless steel or bronze.



TYPE 11-A

Pressed-in packaged unit with spring inside synthetic rubber bellows to protect against corrosion. For hot or cold water, oil, gasoline or soapy liquids . . . pressures to 35 psi . . . temperatures from —65° F. to +212° F.



TYPE 19

An all-purpose seal suitable for handling practically any liquid or gas, including highly corrosive acids and oils.

Low or high temperatures from —100° F. to +450° F. . . . pressures to 200 psi. Incorporates highly efficient sealing cones made of Du Pont's Teflon, which is inert to practically all chemicals.

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Design Abstracts

planes has been shown to result from the presence on the surface of an adsorbed water or oxygen film. In nitrogen, at a relative humidity lower than 5 per cent or in high vacuum, rapid wear with very high friction takes place.

Rapid wear of graphite in a vacuum is readily reduced by incorporation in the powder mix or dispersion of a small amount of a variety of lubricants or adjuvants.

Slipperiness of molybdenum disulfide is not reduced in vacuum, but it cannot be substituted for graphite in brushes operating under high altitude conditions and heavy current loads because the local surface temperatures are high enough to oxidize the MoS_2 to MoO_3, which is highly abrasive.

Both graphite and molybdenum disulfide have high thermal stability. They are both chemically inert, graphite having the edge in this respect, but give little or no protection against corrosion when rubbed into the surface from the powder.

In addition to their use in films on surfaces, these materials are used as mixing agents to improve the wear resistance of other solid materials. For example, the addition of graphite improves the wear resistance of hard rubber, laminated phenolics, asbestos, and metals and alloys.

Laminar solid lubricants are also effective additives to liquid lubricants for improving their lubricity. In this use relatively little benefit is obtained from the addition of small percentages of solid. For maximum effectiveness, at least 10 per cent the solid should be added.

Solid Organic Compounds: Members in this class are metallic soaps, the most common of which are aluminum, calcium, zinc, magnesium, sodium and lithium stearates; waxes, such as microcrystalline waxes, beeswax, spermaceti wax; synthetic waxes such as high molecular weight alcohols, amides, esters, etc.; solid fatty acids, such as stearic and palmitic acids; and fatty esters such as lard and tallow.

Some materials in this class possess self-healing ability, al-

SAGINAW BALL BEARING SCREWS

revolutionize feed storage structure erection

The HARVESTORE Division of the A. O. Smith Corporation of Milwaukee, Wisconsin has come up with a remarkable use for the efficient Saginaw Ball Bearing Screw. Using five Saginaw screws as jacks, a crew of three men can put up a complete HARVESTORE farm feed storage structure in two days by building from the top down — and up! The top section is assembled first, on ground level. It is then raised in this manner: an air-compressor, powered by a 1½ H.P. engine, drives an endless chain which rotates all five screw-jacks simultaneously. After the top section is raised, the next section is assembled, both sections are then raised — and so on. This method saves considerable time, eliminates scaffolding and banishes the hazards of erecting the usual type of feed storage structure. • In the country's best manual and power steering gears, in machine tools, in many of the latest type army and navy aircraft, Saginaw screws are raising, lowering, pushing or pulling loads up to thousands of pounds with a fraction of the power that would be required by any type of thread-to-thread screw. • With wear reduced to a minimum, there is no appreciable increase in back-lash throughout the life of Saginaw Ball Bearing Screws. They can be effectively combined with electrical, hydraulic or pneumatic units. And they simplify service and reduce maintenance requirements (even to the extent of operating effectively with no lubrication). Saginaw screws can be furnished in any size in a complete range of load and life requirements.

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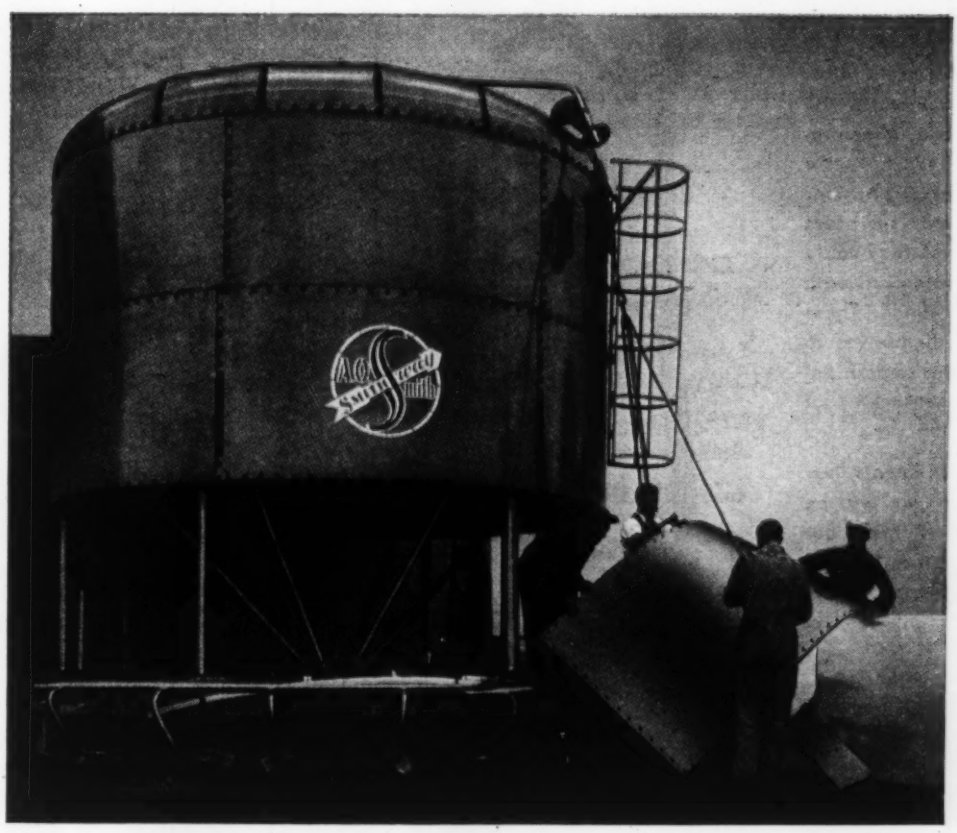

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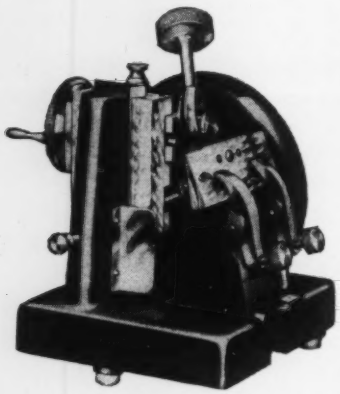

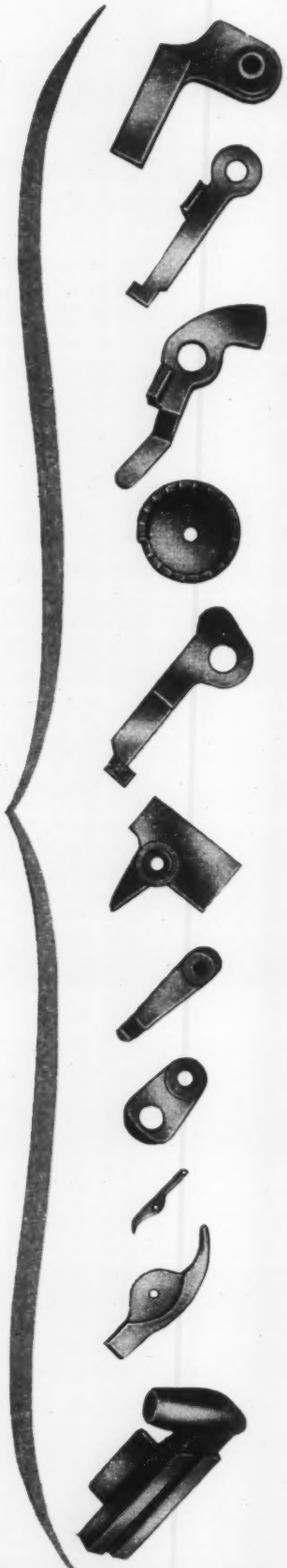

International Equipment Co., Boston, Mass., manufactures the Microtome shown and other precision instruments. For the Microtome, they chose Hitchiner precision investment stainless steel castings because they could get extremely accurate parts with a minimum of machining. These castings also lend themselves to the very high, bright, smooth finish necessary on instruments of this quality.

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Design Abstracts

though the rate of repair of the film is much slower than with liquid lubricants and greases. Stearic acid gives very low friction and good wear reduction on a variety of metals up to temperatures corresponding to the melting point of the metallic stearate. The soaps are all excellent friction reducers but cannot be as readily applied to the surface as the fats and waxes because of their higher melting points and relative insolubility in common solvents.

Most of the waxes and fats can be applied from a solvent. They are also applicable from a melt, or may be rubbed over the surface. They can be incorporated in a solid to improve its lubricity. Mixing of paraffin in soft rubber reduces its friction and wear against soft rubber or other plastics, whereas graphite and molybdenum disulfide are relatively ineffective when used in this manner.

Chemical Conversion Coatings: Best known films in this class are sulfide, chloride, phosphide, phosphate, oxide, and oxalate films. The first four types are generally formed *in situ* at points of incipient seizure as a result of reaction between additives in an extreme pressure lubricant and the surface of heavily loaded rubbing parts.

The thin film of oxide which occurs on all base metals, even immediately after cleaning by abrasion or cutting, acts as a solid lubricant, although not the best, because of its poor elastic properties and relatively high shear strength.

Phosphate and oxalate coatings are used as a supplement to other lubricants, both liquid and solid. Phosphate coatings, in particular, have extensive use in a variety of operations in forming and working of metals, usually in combination with other lubricants. They are also widely used to assist run-in, particularly in applications where scuffing is likely to occur.

When chemical conversion coatings are used in combination with other solid lubricants, a surface is produced which outwears by a

very large factor either lubricant alone.

Soft Metals: The extent to which a thin film of a soft metal on a hard metal substrate reduces friction has been demonstrated by others. Coefficients of friction as low as 0.04 have been obtained for an indium film 1.6×10^{-4} in. (4×10^{-4} cm.) thick on steel. Soft metals used as lubricants in practice are indium, lead, tin, zinc, copper and barium.

Polymer Films: Experience with plastic films as solid lubricants is very limited, but the preliminary results on porous metal impregnated with polytetrafluorethylene (Teflon) are very interesting. Basic studies indicate that the mechanism of friction for plastics is the same as that for metals except for Teflon which has a very low coefficient of friction.

Studies to date on wear of plastics like nylon and fluorinated polymers indicate that their chief limitation lies in poor thermal conductivity. Frictional heat is not dissipated fast enough from its source to prevent the local temperature from rising above the melting point of the plastic and galling ensues. Impregnation of porous metal provides the necessary heat conductivity but is a difficult process.

Miscellaneous Soft Solids: A large variety of inorganic solids which do not clearly fit into any of the classes above comprise this class. Examples are basic lead carbonate or white lead, used in threading compounds; lime, used as a carrier in wire drawing; talc and bentonite, used as fillers in greases for cable pulling.

Applications: A solid lubricant is only needed where the use of fluid or semifluid lubricants is impossible, undesirable or ineffective. It will not in general substitute for a satisfactory fluid or semifluid lubricant, although it may supplement it. All types of solid lubricants are suitable for extremely low temperatures.

From a paper by the same name presented at the Eighth Annual

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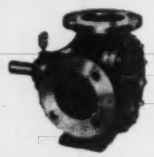

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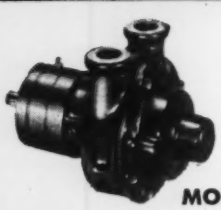

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Design Abstracts

Meeting of ASLE in Boston, Mass., April, 1953.

High-Speed Photography —A Design Tool

By John H. Waddell

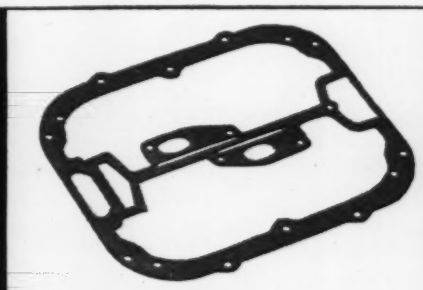
Wollensak Optical Co.
Rochester, N. Y.

HIGH-SPEED photography can be effectively employed in research and development, in manufacturing processes and in performance tests. In mechanical operations, parts are usually moving too fast for the eye to see. For example, a shaft which is rotating at 3600 rpm appears only as a blur when observed visually, or when recorded with a normal-speed motion picture camera. Through modern methods in photography, however, that shaft can be slowed to a speed of 1 revolution every 8⅓ seconds with a 16 mm high-speed motion picture comera, or one revolution every 16 2/3 seconds with an 8 mm high-speed camera. This is often called "time magnification". The high-speed motion picture camera is fast becoming a complement to the engineering handbooks and textbooks; it is an ideal instrument for the analysis of most types of rapid motion.

Photographic Composition: When high-speed motion pictures are used, it should be remembered that it is usually desirable that each component part should be photographed separately. It is difficult to analyze a large number of items moving simultaneously on a screen. Rules of simple photographic composition also hold in taking pictures for analytical purposes.

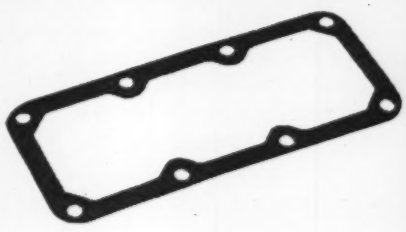
Light Sources and Films: Color film can be used as easily as black-and-white film with light sources that are available today. Special painting or finishing to increase subject contrast is no longer necessary; natural color themselves will delineate component parts. Color film can be easily exposed at rates up to 8000 frames per second with incandescent tungsten sources and in excess of 1000

MIL-G-6183, Type II Soft
Armstrong's DC-167



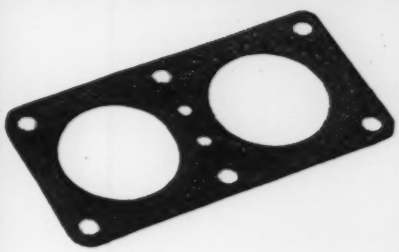
MIL-G-6183, Type I Firm
Armstrong's NC-711

MIL-G-6183, Type I Medium
Armstrong's NC-710



MIL-G-6183, Type II Medium
Armstrong's DC-100

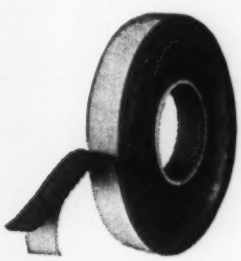
MIL-G-6183, Type II Firm
Armstrong's DC-113



MIL-G-6747
Armstrong's DK-149

These nine different materials meet most government specs for cork-and-rubber gaskets

MIL-G-6183, Type I Soft
Armstrong's NC-709



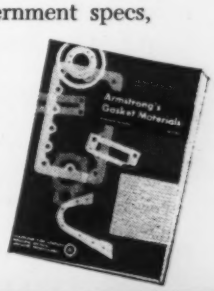
MIL-T-6841
Armstrong's DK-153 and
RK-3048

MIL-G-17539
Armstrong's RK-375

When you need a cork-and-rubber gasket to meet government specifications, check with Armstrong. Each of the Armstrong materials shown above is made to meet one of the nine principal specifications for cork-and-rubber gaskets. Sheets and tapes are available immediately from stock, parts cut to your order take only a little longer.

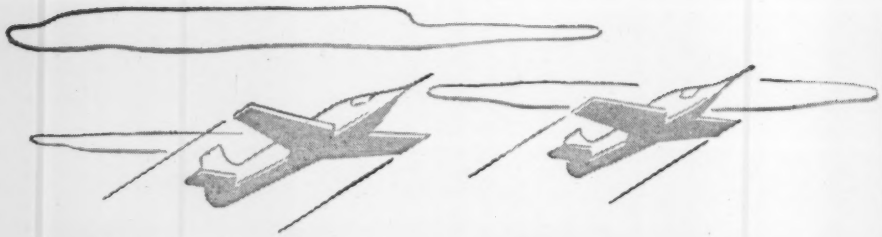
For samples and full information, call your nearest Armstrong Industrial Division Office or see the "Armstrong's Gasket Materials" section of Sweet's product design file.

Free gasket data book. Send for a free copy of the new 1953-54 edition of "Armstrong's Gasket Materials" for your file. It's packed with useful information: contains current government specs, tentative SAE-ASTM specs, plus sections on cost reduction, gasket tolerances, flange design, etc.

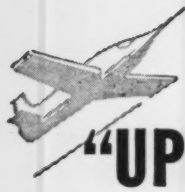


For your free copy, write to Armstrong Cork Company, Industrial Division, 7111 Dean Street, Lancaster, Pennsylvania.

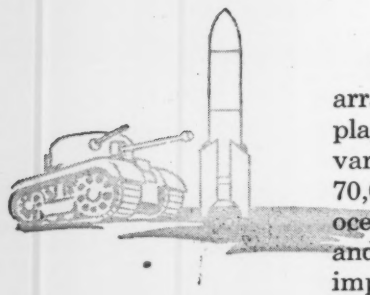
Armstrong's Gasket Materials



Pacing Relay Progress



"UPSTAIRS" as well as down



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frames per second outdoors on bright, clear days. With new color films which are being developed, performance now obtained with high-speed commercially available black and white film will be equalled.

Auxiliary equipment is being designed to increase adaptability of high-speed cameras. Picture taking rates are easily adustable since series motors are used and the voltage supplied governs picture taking rate, no matter whether it be ac or dc. These picture taking rates vary from 150 to 16,000 frames per second and in frame sizes from 8 mm to full-frame 35 mm. Photographic quality of rotating prism cameras is approaching that of intermittent cameras in sharpness, contrast and resolution. In some high-speed cameras, steadiness and lack of weave or bounce is better than the intermittent cameras.

Engineers and designers are finding numerous possibilities for improved design, better performance and decreased engineering costs through use of high-speed cameras in motion analysis.

From a paper entitled "High-Speed Photography and Mechanical Analysis" presented at the Fall Meeting of ASME in Rochester, N. Y. October, 1953.

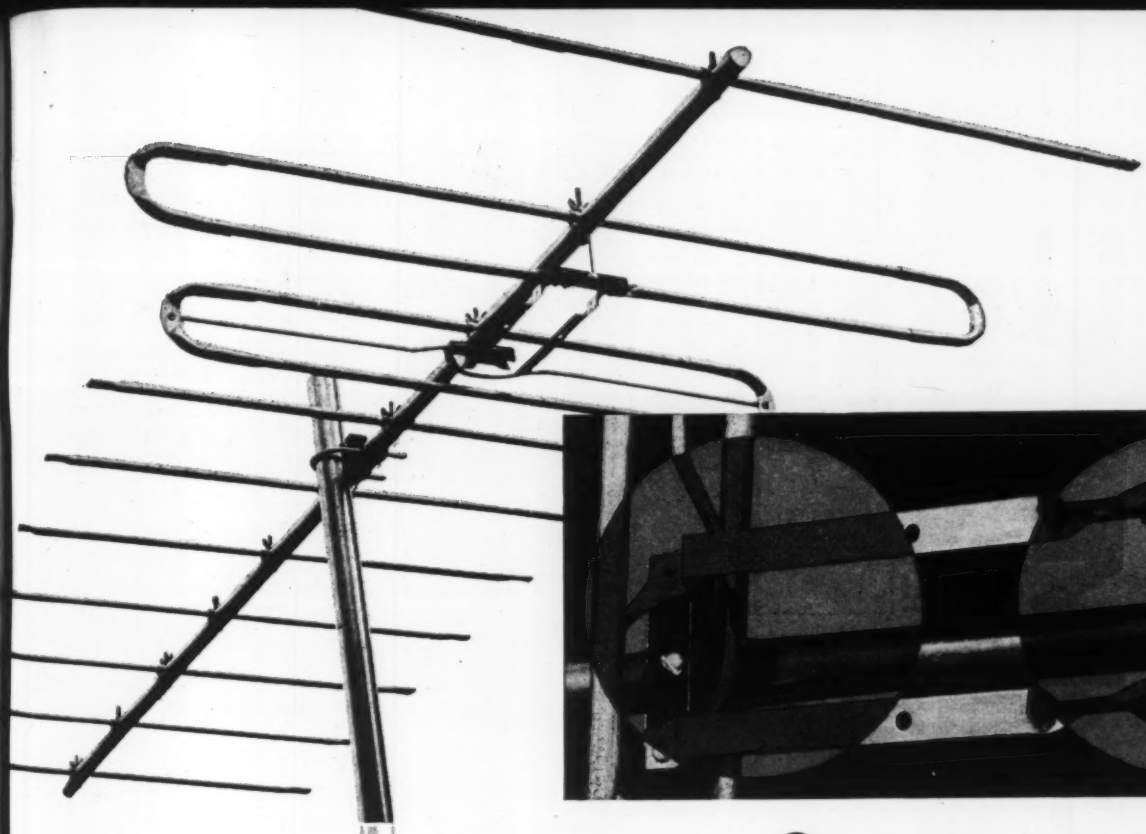
Synthetic Lubricants for High Sliding Velocities

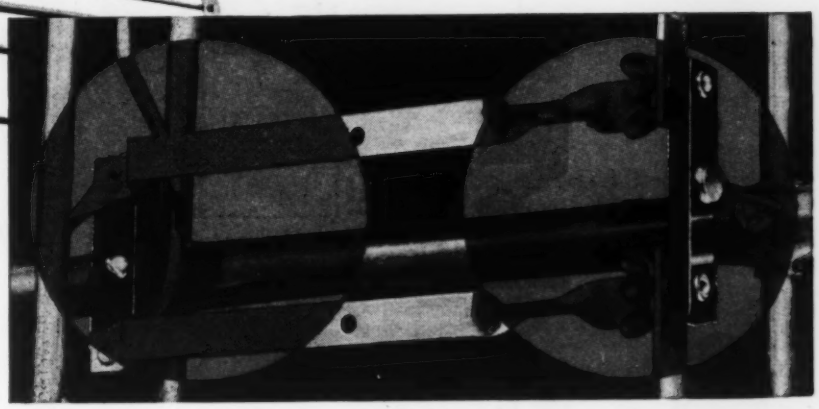
By R. L. Johnson, M. A. Swikert and E. E. Bisson

Lewis Flight Propulsion Lab
Cleveland, O.

A number of synthetic fluids have either been considered or merit consideration as lubricants on the basis of their viscometric and thermal stability properties. Unfortunately boundry lubrication and friction data on these fluids are limited. In consequence, boundary lubrication studies were made for steel-on-steel lubricated with a number of synthetic fluids of various classes.

Experiments were conducted with a kinetic friction apparatus consisting of a steel ball sliding





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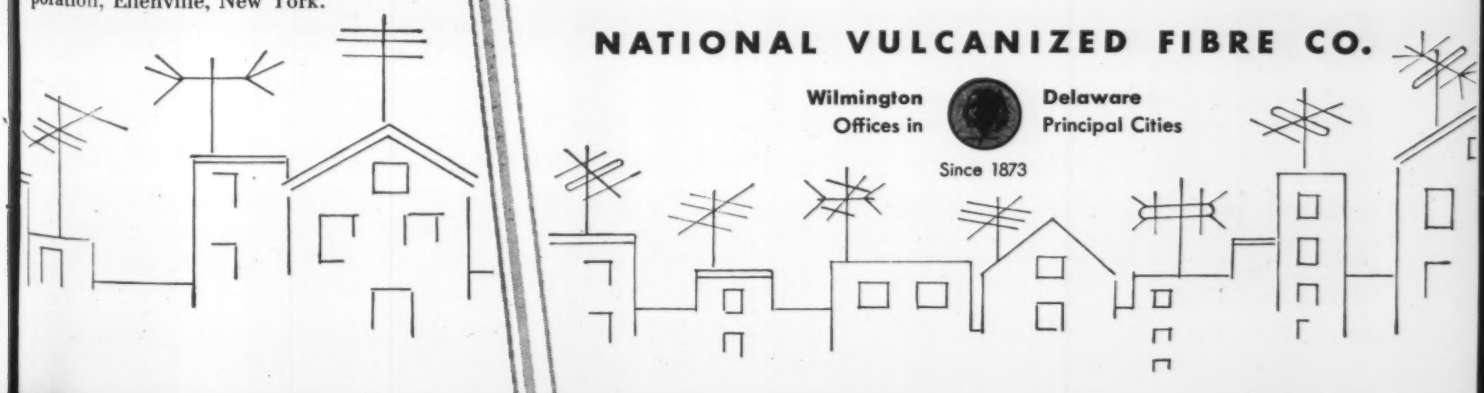
Illustrated: Futuramic Model 1173 broad band Yagi antenna covering channels 7-13, Channel Master Corporation, Ellenville, New York.



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Design Abstracts

on a lubricated, flat steel disc. Data were obtained on very thin films of synthetic fluids and petroleum at sliding velocities from 75 to 12,000 feet per minute and with a load of 269 grams (initial Hertz surface stress, 126,000 psi). Fluids studied included diesters, polyethers, a silicone, a silicone-diester blend, a silicate ester, phosphonate esters, a halocarbon, and two petroleum lubricants.

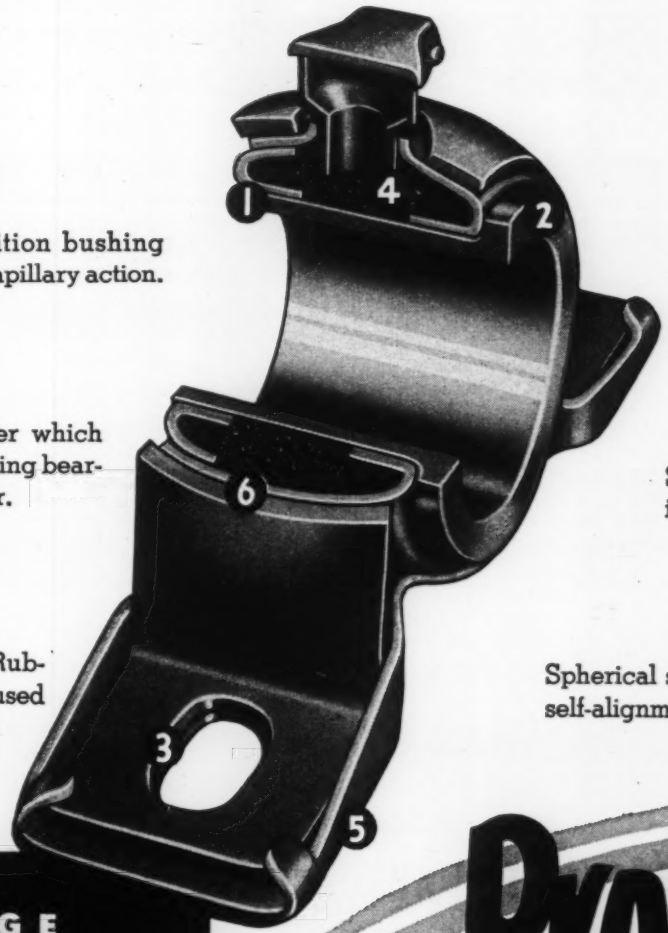
Fluids Properties: Commercial fluids were used without special treatment inasmuch as previous unpublished data obtained had indicated that percolation of diesters through silica, alumina, and Fuller's earth had no measurable effect on frictional properties under extreme boundry lubrication conditions. No marked effect of percolation on friction was found with synthetics such as diesters and polyglycol ethers.

The diesters are the class of synthetic fluids most widely accepted as aircraft lubricants and have been considered favorably for some time. Diesters have very good viscometric properties and effective oxidation inhibitors have been developed for specific fluids.

The polyethers were among the first commercially available synthetic lubricants. They have viscometric properties superior to those of the petroleum oils. Several polyether fluids have desirable thermal stability properties in that they do not generally form solid decomposition products. Theoretically, the fluids crack and the resulting fractions volatilize without leaving any residue.

Silicones have the best viscometric properties of any known liquids. The silicones, however, have two limitations: (1) inadequate oxidation resistance or thermal stability and (2) poor lubricating effectiveness, particularly on steel.

Petroleum Oils: Data for petroleum oils (MIL-O-6081a, grades 1010 and 1005) were taken for comparsion with the synthetic fluids. In the region of effective boundary lubrication, data show that viscosity had no effect on friction and surface failure. Both



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2 Bushing has shoulder which provides self-lubricating bearing surface for collar.

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4 Absorbent filler holds oil in reservoir and prevents over-lubrication.

5 Split Pressed Steel Housing is light and strong.

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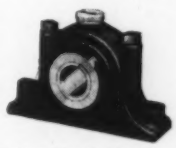
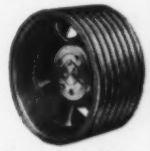


Dodge-Timken Bearings



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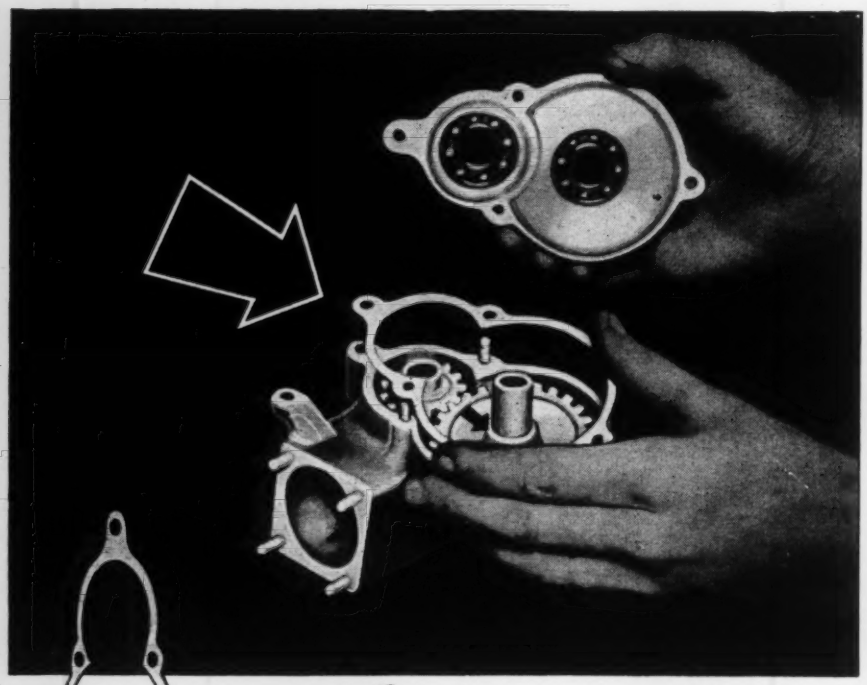

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Design Abstracts

grade 1010 and 1005 produced friction coefficients from 0.06 to 0.10 in the range of sliding velocities where they were effective lubricants. Incipient surface failure occurred at 3000 feet per minute with grade 1010 and at 2400 feet per minute with grade 1005.

Failure is believed to be a function of the rate of heat energy released in sliding. At high sliding velocities, the increased amount of heat generated causes physical desorption of, or lubricant decomposition in, the boundary film, allowing metallic contact. For lubricants within the same class, the sliding velocity at which failure takes place (critical velocity) is believed to be a function of the high temperature stability of the particular lubricant.

Diesters: All the diesters studied provided effective lubrication at sliding velocities at least twice as high (7000 to 9000 fpm) as the grade 1010 petroleum oil which has similar room temperature viscosity.

With all diesters, in the range of velocities where effective lubrication was obtained, the wear-areas of the rider (ball) specimens showed both the absence of welding and the presence of a tan surface film. When incipient failure of the lubricated surfaces occurred, the tan film became mottled with small areas of uncoated and slightly disturbed metal appearing. The observed surface stain or film may be a reaction product of the diester and the steel surface.

Polyethers: Although they are effective lubricants, the polyalkylene glycols do not produce quite as low values of coefficient of friction as were obtained with either the petroleum lubricants or the diesters. The polyalkylene glycol fluids provided effective boundary lubrication at sliding velocities substantially higher than those at which the petroleum oils were effective but they were not effective at sliding velocities as high as those for the diesters. Incipient surface failure occurred at

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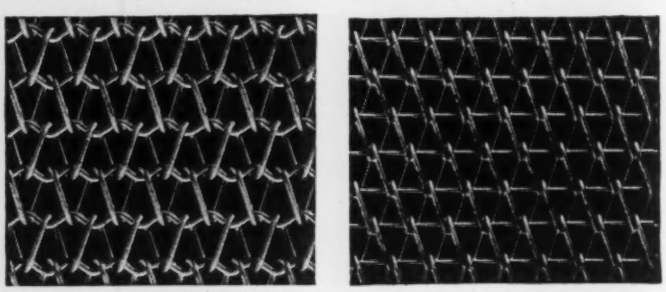

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around 5000 feet per minute for the water-insoluble and at 6000 feet per minute for the water-soluble polyakylene glycols.

The tripropylene glycol *n*-butyl ether is marketed as a heat-transfer fluid and is not commercially represented as a lubricant. This material was studied in order to determine its lubricating properties. With the heat-transfer fluid, friction was high and surface failure was observed over the entire range of sliding velocities. This indicates that good lubricating ability is not common to all polyethers.

Silicone-Diester Blend: The silicone (polydimethyl siloxane) produced mass surface failure at all conditions of the experiment, and the friction coefficients were considerably higher than with most other lubricants.

The lubricating properties of silicones can be markedly improved by blending them with 30 to 50 per cent by volume of solvent. Data were obtained at high sliding velocities with a blend of 1/3 di-2 ethylhexyl sebacate in a silicone fluid. At 100 F, viscosity of this silicone-diester blend was appreciably less than that of the polydimethyl siloxane. This blend was a very effective lubricant; friction coefficients were in a range that are common to effective boundary lubrication and there was no excessive wear or evidence of surface failure until the sliding velocity exceeded 10,000 feet per minute. The degree of incipient surface failure was greater at sliding velocities of 11,000 and 12,000 feet per minute but extreme mass failure was not observed.

Silicate and Phosphonate Esters: The alkyl silicate ester [tetra (2-ethylhexl) silicate] is an effective boundary lubricant at sliding velocities to 9500 feet per minute. Mass surface failure occurred at 10,000 feet per minute. The friction coefficients obtained with the silicate ester under conditions of effective boundary lubrication were as low as those experienced with any of the fluids studied.

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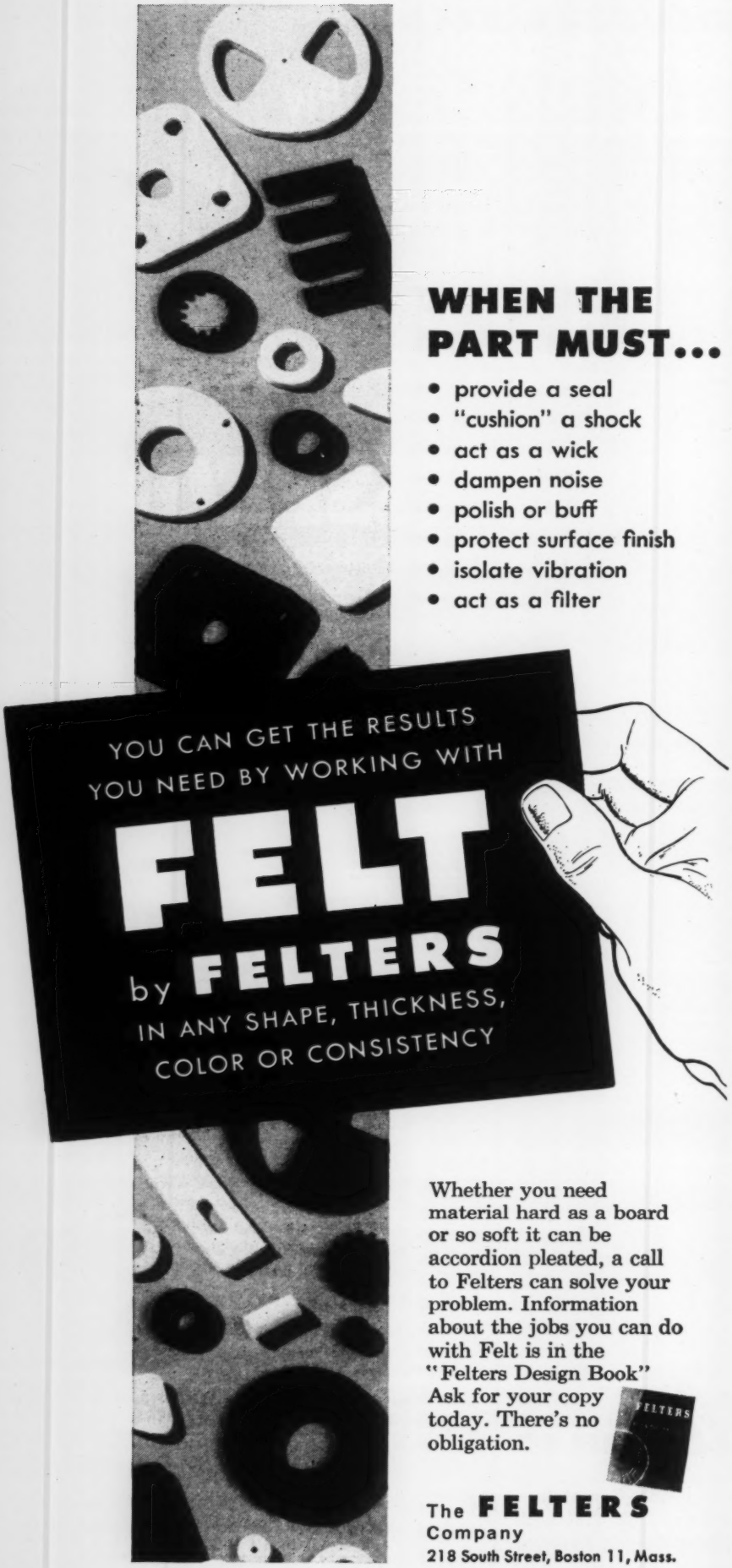
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Since one of the decomposition products of the silicate ester is silica, the sharp break which occurred in the friction curve might be a result of the formation of that harmful material as surface failure occurred.

Lubrication data for the two phosphonate esters were taken. The dioctylbenzene phosphonate provided effective boundary lubrication at sliding velocities up to 5000 feet per minute, at which incipient surface failure was observed. The dioctylisooctene phosphonate was a slightly better boundary lubricant than the other phosphonate; incipient surface failure occurred at 6000 feet per minute and mass failure occurred at 6500 feet per minute.

Halocarbons: Data were also obtained for a halocarbon (trifluorovinyl chloride polymer) and the results indicate that friction increases as the sliding velocities increase. Visual studies of the surface did not show any indication of incipient surface failure until a sliding velocity of 3000 feet per minute was obtained. Mass failure apparently occurred to the surface at 7000 feet per minute, although failure was not as drastic as that experienced with other types of lubricants. The unusual behavior of this fluid may be accounted for on the basis of decomposition of the lubricant to the form compounds having "extreme pressure" characteristics. The decomposition might have produced a chlorine compound which acted as the "extreme pressure" agent.

Conclusions: Sliding-friction data and surface-failure properties show that a number of synthetics including diesters, polyethers, a silicate ester, and phosphonate esters are more effective boundary lubricants at high sliding velocities than petroleum oils of comparable viscosity at 100 F. The breakdown of effective lubrication takes place at a much higher sliding velocity with these synthetics than is obtained with the petroleum oils.

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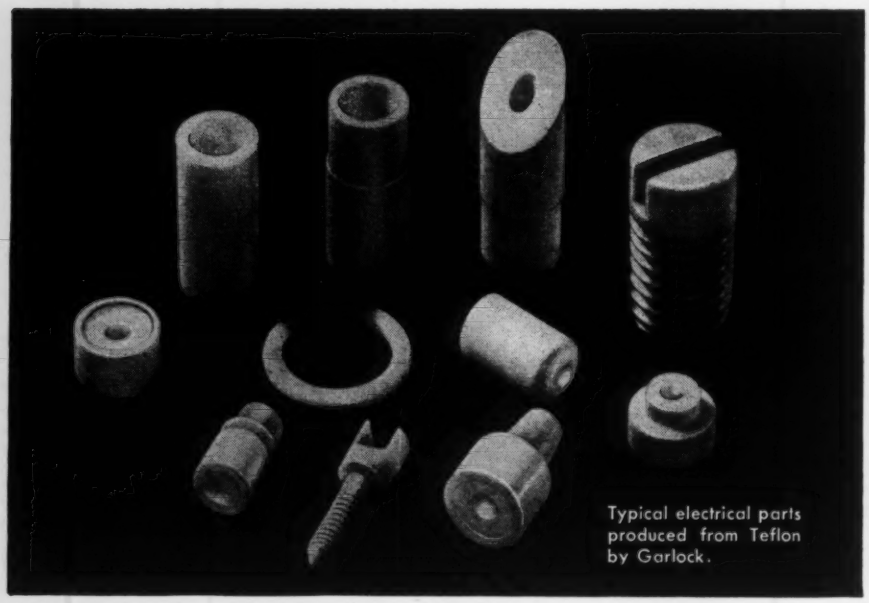

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Design Abstracts

to be a much more effective boundary lubricant at high sliding velocities than either the silicone or the diester.

A diester failed to lubricate nonreactive surfaces which indicates that the lubrication mechanism for diesters may involve chemical reaction with the lubricated surfaces.

From a paper entitled "The Lubrication Characteristics of Synthetic Lubricants at High Sliding Velocities" presented at the Eighth Annual Meeting of ASLE in Boston, Mass., April, 1953.

What Management Expects from the Engineer

By H. B. Riehl
Proctor and Schwartz Inc.
Philadelphia, Pa.

WHAT management expects from the engineer depends to a great extent on management itself. Management can and does vary from mismanagement to enlightened, progressive management.

Technological advances in recent years in all industry have brought such a number of engineers into management, that today when engineers as a group consider this question, the situation is no longer one of academic interest; rather it becomes a matter of searching, self-analysis. At times the engineer stands back and discusses in a detached manner the policies and decisions of management. As long as he persists in this attitude, the engineer really does not consider himself part of the management team. This attitude on the part of the engineer is the result of either management's failure to spell out and make clear the objectives, policies and plans of management to the engineer, or the engineer's unwillingness to accept his responsibility as a member of the management team.

Adaptability of Engineers: In the search for men to help solve the complex problems of modern industry, progressive management has found that the engineer's basic

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The ocean is in reality a number of layers or currents of water "separated" by differences in temperature. The temperature at various levels is determined by lowering a small measuring instrument, called a Bathythermograph, into the water.

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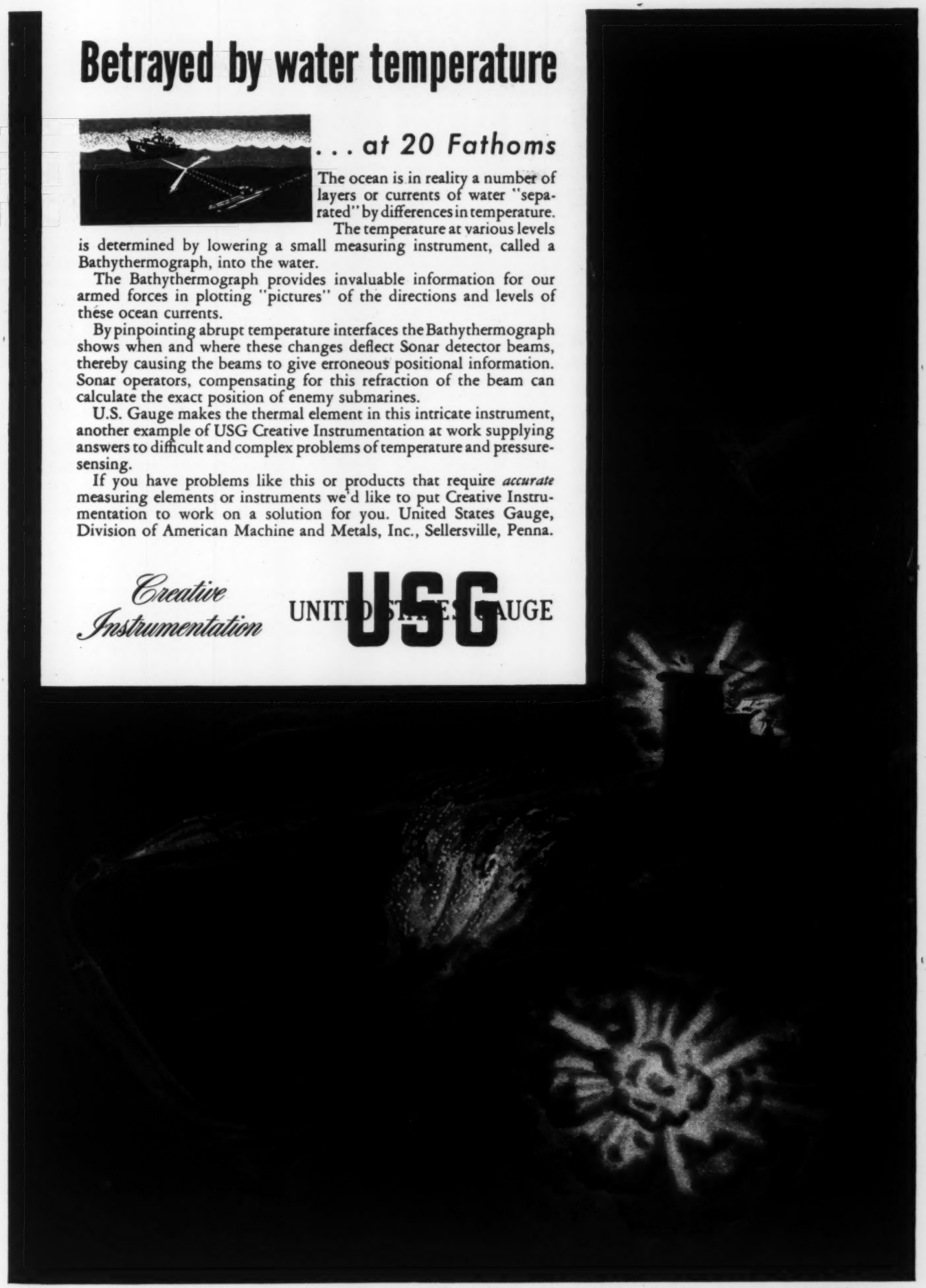

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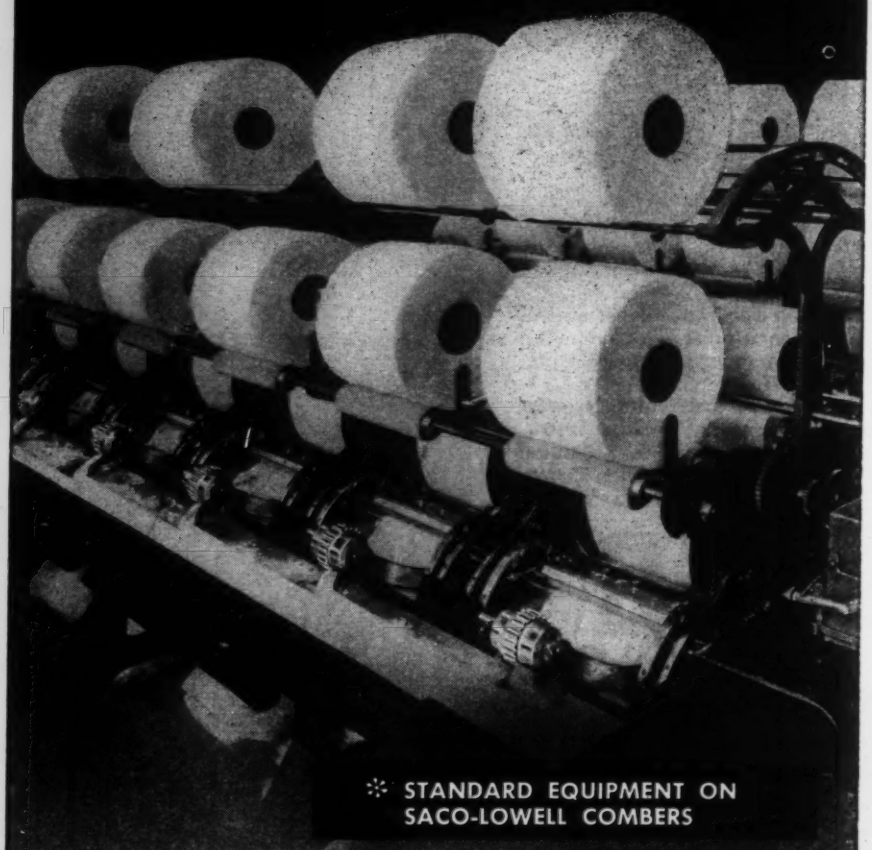

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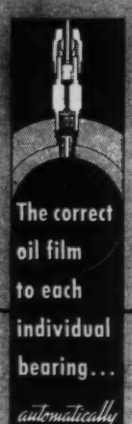

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248

Design Abstracts

technical training has prepared him for such work. The engineer, generally trained in the field of science and mathematics, and having highly specialized training in a specific field, such as chemistry, mechanics, electronics, has been trained to think things through for himself, to sort out facts from fancy, and to make decisions based on facts. In addition, most good engineering schools, recognizing that the engineering student is destined to take part in the management picture, teach the fundamental principles of scientific management. With this background and training, management has the right to expect from the engineer four basic qualities: (1) clear and objective thinking, (2) leadership, (3) ideas, (4) willingness to accept the responsibilities of his position on the management team when given the opportunity.

General Qualities Required: Management is primarily concerned with the making of decisions to act. Decisions are only as good as the accuracy of the facts presented; therefore, management expects the engineer to find the facts and present them by clear and objective thinking, free of emotion and without bias or evasion. Management also expects clear and objective thinking in the engineer's relations with the so-called nontechnical departments of the business, such as cost analysis, sales analysis, expansion program studies and other industrial problems.

Leadership is expected from the engineer wherever he may be placed in the management team. It is only through leadership in all levels of management that the objectives, policies and plans of management may be made clear to all concerned.

The engineer is expected to have ideas; ideas as to product; ideas as to the production of the product with regard to quality and cost that will make it competitive in its field; ideas as to the proposed presentation of new methods and processes and the treatment of personnel responsible to him so that innovations in plant operation will be received with open mindedness rather than with an attitude of passive resist-

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That's right—one-third h.p. motors are the popular ones when it comes to powering cellar drainers. Where dependable, trouble-free service counts, Delco Motors are the long-time favorites. Manufacturers know the Delco name gives their products added value.

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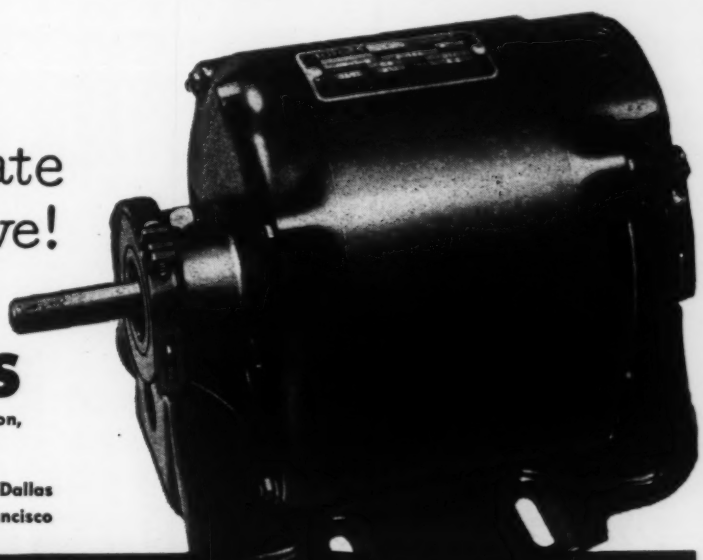

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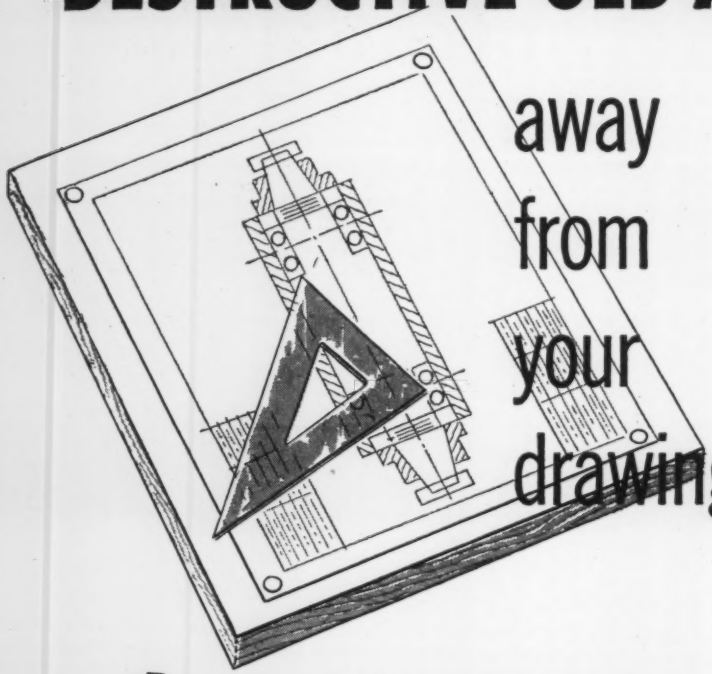

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ance or open revolt.

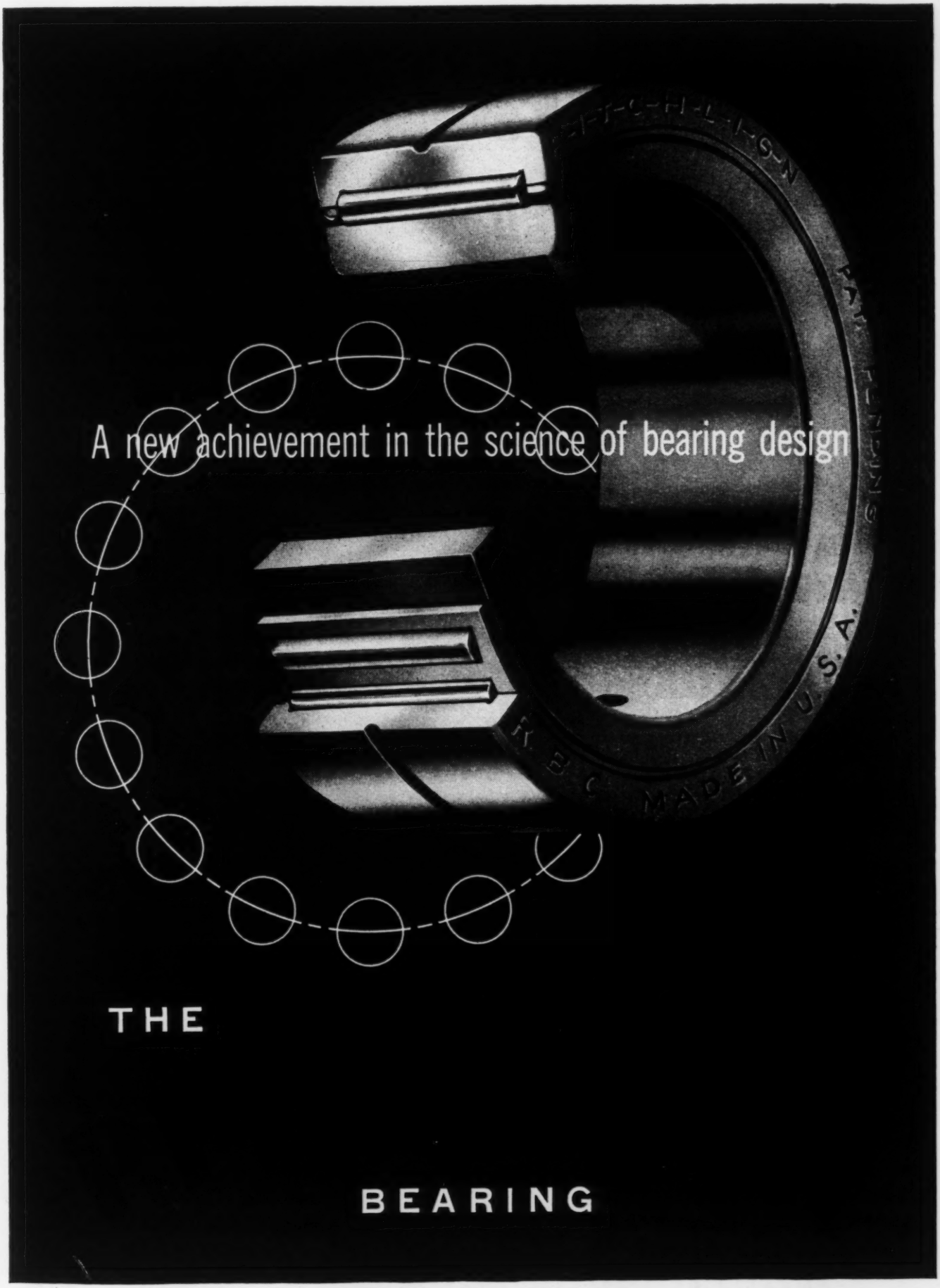
Management expects the engineer to strive for development of mature and sound judgment, for without it clear and objective thinking is difficult, and constructive and inspiring leadership almost an impossibility. Ideas die when sound and mature judgment is not employed in evaluating them.

Above all, the engineer must consider the overall welfare of the company when making decisions at his level in the management structure.

Specialized Qualities Expected: Engineers, because of their personal inclinations, usually find themselves placed in one of five major branches of engineering, namely: sales, research, design, production or industrial. From each of these divisions, management expects certain definite results.

SALES ENGINEER: Management has the right to require the sales engineer to know his product, as well as the function the product performs for the consumer. Through this knowledge, he is able to ascertain the needs of his consumer and to recommend the proper equipment or product that will be of utmost utility to the consumer and be made at a profit by his own company. In addition, management expects the sales engineer to furnish information and data relative to product or services that will assist management to formulate its long range policies regarding established as well as new products and service. These data also influence the decisions of all the other engineering departments regarding product design, research and manufacturing.

RESEARCH ENGINEER: Management expects the research engineer not only to develop the idea of the sales engineer, but also ideas from other branches of the business, and ideas that may have suggested themselves from products previously developed. In addition, management thinks the research engineer should exercise judgment in his decisions in order that the men under his direction and his budget allowance will not be wasted on projects which are interesting but not per-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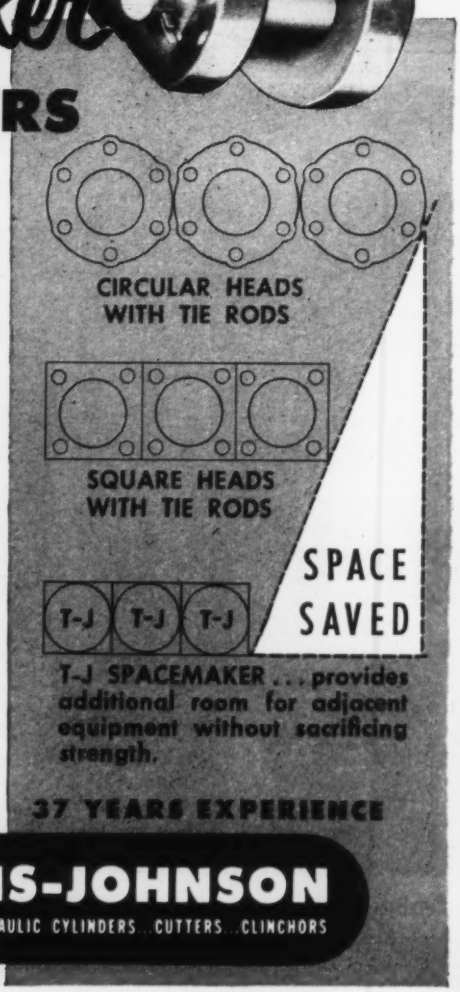
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Design Abstracts

tinent to the company's long range program.

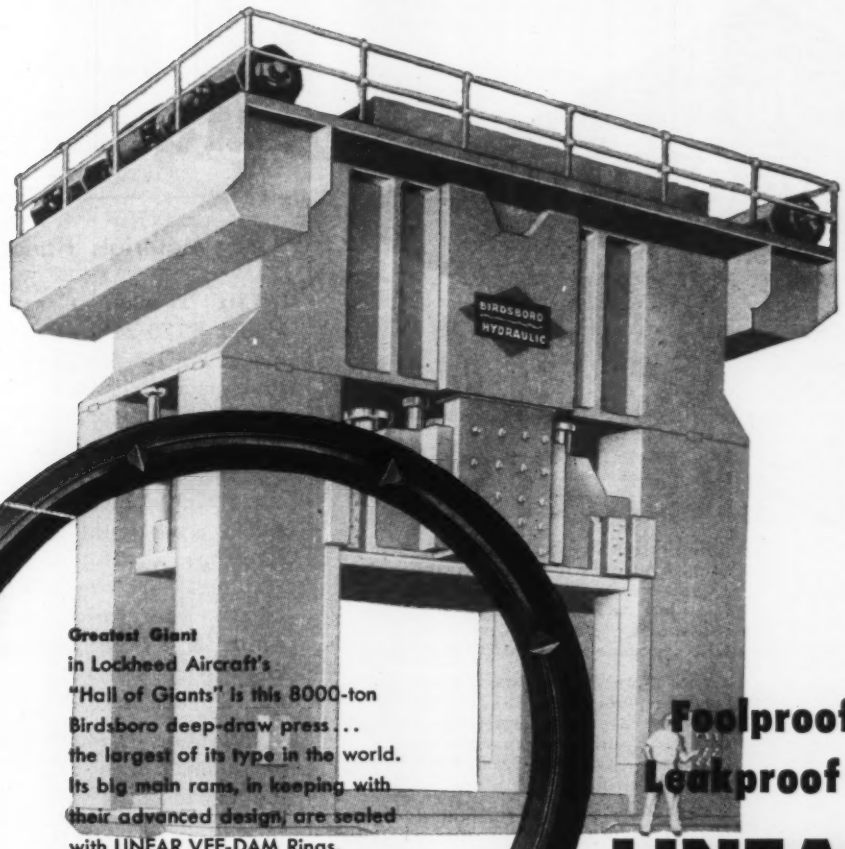
DESIGN ENGINEER: The design engineer must design a product of maximum utility at a cost that will give a profit to allow the company to maintain its competitive position in its field and keep abreast of the development of new processes and materials that would improve and possibly reduce the cost of its product. Management expects the design engineer to organize his efforts to permit the engineering personnel to carry out long range policies of the company, such as simplification of product lines and parts standardization.

PRODUCTION ENGINEER: Management feels that the production engineer should know the capabilities, capacity and potential capacity of the existing production plant and should schedule material and men to meet the quota set up by the company's order file. In addition, the production engineer is expected to produce the product as specified by the design engineer at or below the estimated cost.

INDUSTRIAL ENGINEER: Management expects the industrial engineer to provide ideas, as to job simplification, improved plant layouts and materials handling, equipment improvement and replacement, and the setting up and carrying out of bonus and incentive systems.

In addition to the specific requirements mentioned for the various engineering groups, management expects each engineer in his sphere to do his part in the teaching and training of personnel in order to supplement the company's long range program for the selecting, acquiring and training of engineering personnel. Finally, management expects the engineer in any specific group of engineering endeavor to take the initiative in acquiring knowledge in the fields of finance, advertising and personnel relations, particularly as they influence the engineer's situation as a member of the management team.

From a paper entitled "What Management Expects from the Engineer" presented at the Management Conference of ASME in Detroit, Mich., April, 1953.



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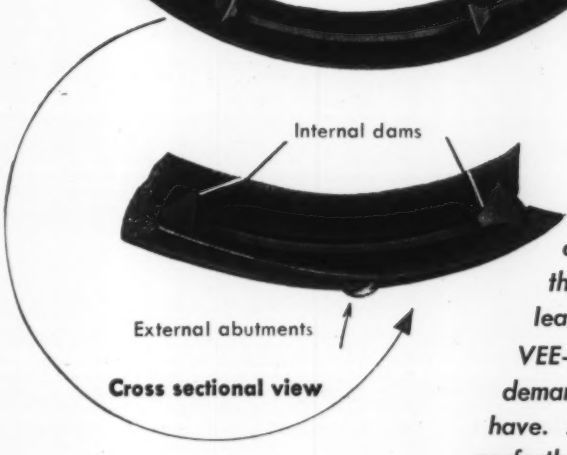
LINEAR VEE-DAM RINGS



Cross sectional view

The unique design of LINEAR VEE-DAM Rings makes possible, for the first time, a split "V" ring packing that is really leakproof . . . ideal for hydraulic presses, pumps and pneumatic equipment.

A look at the close-up view of a VEE-DAM Ring will tell you why they seal so effectively. Those sturdy rubber dams, faced in opposite directions, are moulded into the groove hinge area of the ring, completely eliminating leakage between rings.

VEE-DAM Rings are easier to install because they don't demand the precise fitting that ordinary rings should have. And they last longer, too, because they seal perfectly tight with a minimum gland load.

Made of a choice of fabric reinforced synthetic rubbers, LINEAR VEE-DAM Rings are individually engineered for your application. Write or call LINEAR for complete information.

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New Machines

Materials Handling

Lift Trucks: Gasoline-powered Model FT75-24 and diesel-powered Model FTD75-25 are rated at 7500-lb capacity at 24-in. load center from face of forks and are available in standard lift heights of 72, 84, 108 and 114 in. Features include single lever full range gear shift; centerpoint automotive-type steering; hydraulic brakes; self-aligning lift cylinder. Overall length, less forks, is 100½ in.; width is 42 in. Trucks can turn in 77¼-in. intersecting aisles. *Buda Co., Harvey, Ill.*

Traveling Broach Rack: Employs small crane and hoist for lifting broaches. Facilitates handling of heavy broaches where two or more passes are required and where it is not feasible to remove part between passes. A roller mounted shuttle rack is connected with the broach ram; as the ram moves, the rack moves with it so that when broaching pass is finished, the rack is immediately above broach to be removed. Padded hooks hoist broach to rack. Ram returns to loading position with rack following. Crane picks up next broach from rack and lowers it into broaching position, and broach is attached to puller for next pass. *Colonial Broach Co., Detroit, Mich.*

Heavy-Duty Fork Truck: Traveloader with 30,000-lb capacity loads from the side. Loads are carried inboard on the load rack; truck can travel at speeds up to 30 mph. Features hydraulic steering and hydraulic stabilizing jacks which are used during unloading. Lift height is 12 ft; length, 25 ft; width, 9 ft; height, 10 ft. *Baker Industrial Truck Div., Baker-Raulang Co., Cleveland, O.*

Scoop Attachment: Used on manufacturer's hydraulically powered trucks; handles fine bulk materials such as coal, salt, sulphur, grain. Hydraulic power is furnished by same system which oper-

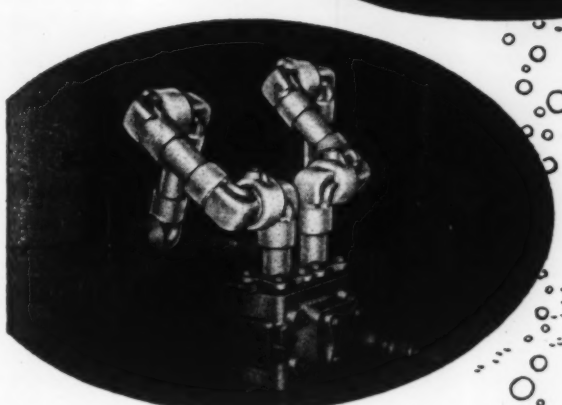
Safety of its people and property, plus increased efficiency and economy of operation, were the chief considerations which turned Johnson Motors to Chiksan Swivel Joints.

Johnson Motors die-casting department, one of the largest in the Middle West — and the largest captive plant in this country — selected Chiksan hydraulic swivel joints when it converted its machines from flammable oils to nonflammable hydraulic fluids.

Forty-eight package die casting machines are operated on a staggered three shift basis, producing more than 400 aluminum alloy die castings ranging from ½ ounce to 11 pounds in size. Hydraulic systems are operated at pressures up to 2000 psi, with average total die forces in the range of 300 to 500 tons. Castings are made at temperatures between 1100° and 1200° F.

Chiksan ball-bearing swivel joints have helped to reduce fluid losses from 40,000 gallons per year to 10,000 gallons. In contrast to former loss of from 1 to 3 gallons in repositioning bolted lines, Chiksan joints permit resetting of table level with virtually no fluid loss. Time consumed in resetting table levels has been reduced from 2 men and 1 hour to one man and 15 minutes of time.

This story is typical of the many ways thousands of manufacturers are using Chiksan ball-bearing swivel joints for greater safety, efficiency, and economy in their operations.



Chiksan ball-bearing swivel joints installed on Lester-Phoenix die-casting machine helped Johnson Motors meet its fluid cost problems.

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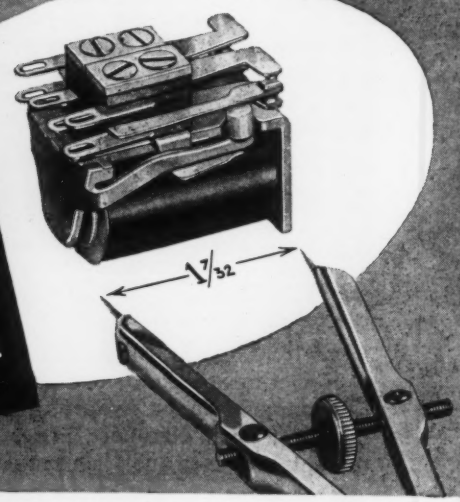

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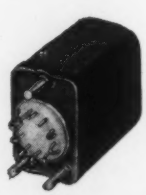

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Tier Lift Truck: For use in changing dies, jigs, etc. New die is placed on top roller shelf, transported to press; other die is removed to bottom roller shelf; and new die is lowered in line with press for setting into place. Truck has gas-electric drive consisting of a small 12-hp, four-cylinder, four-cycle gasoline engine driving a 12-v dc generator. *Market Forge Co., Everett, Mass.*

Metalworking

Column Press: One adjustable stand accommodates air cylinders with 3 or 4-in. bore, either single or double-acting. Upper ram of double-acting presses has depth stop nuts and collars to regulate the stroke within limits of cylinder. Single-acting press has neither upper ram nor depth stop adjustment. Column is solid steel; table is machine surfaced but not hardened, to allow mounting of special tooling. *Mead Specialties Co., Chicago, Ill.*

Burring - Chamfering Machine: Universal Burr-Master burrs and chamfers the entire tooth form of both helical and spur gears from ⅝ to 9½ in. pitch diameter, as well as external straight and involute form splines. Finishes gears with 22 teeth at a rate of more than 600 per hour, at 80 per cent operating efficiency. Changeover normally requires 10 minutes. Precision-ground tool holder nests and is keyed in two directions. Four socket-head screws hold the tool block in position. Work-holding fixture is located on fixture-mounting rails and positioned over hardened and ground dowels. It also is secured by four socket-head screws. Driven by ½-hp motor; two motors are used on two-station

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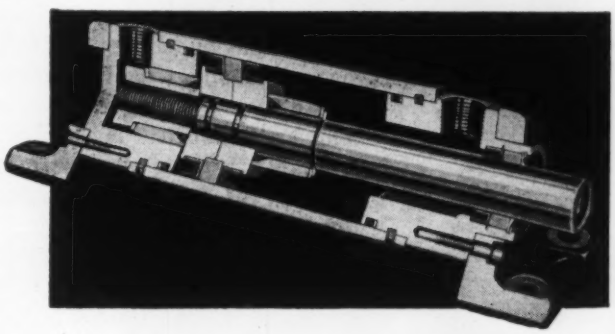

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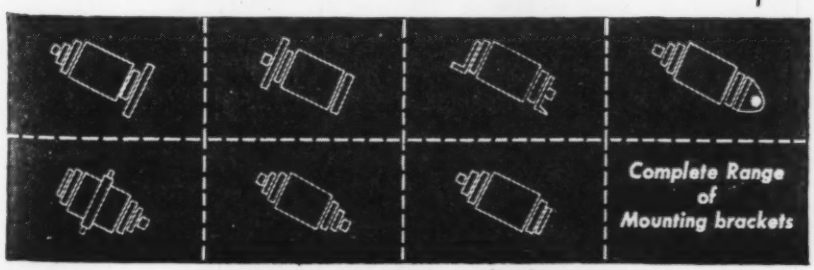

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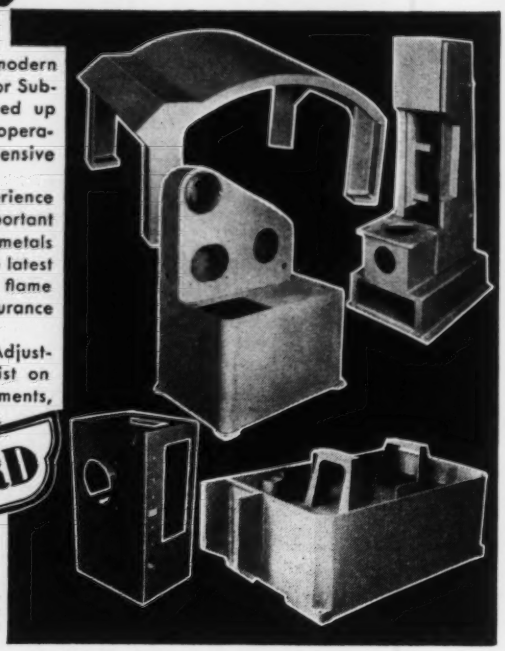

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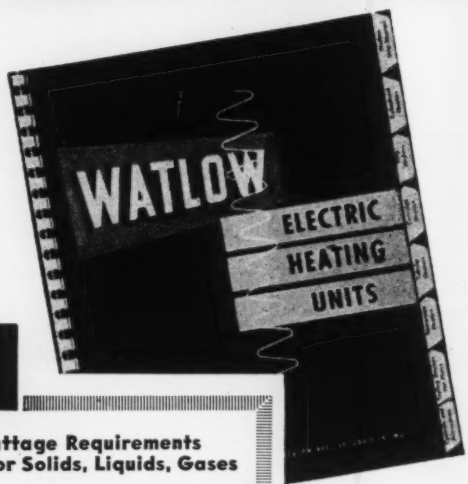

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New Machines

machines. Depth of cutting stroke is infinitely adjustable between limits. Four models are available for gears from ⅝ to 6½ in. pitch diameter and four others for gears from 3 to 9½ in. pitch diameter. *Modern Industrial Engineering Co., Detroit, Mich.*

Tube Expander: Hydraulically powered vertical unit for expanding and sizing metal tubing, particularly copper tubing in evaporator and condenser coil assemblies. Expansion mandrels mounted on 1-in. centers expand sixty ⅜-in. diameter tubes 0.020-in. Another set of sixty mandrels, through which the expanding mandrels feed, size ends of tubing for soldered returned bend fittings by expanding them an additional 0.026-in. Cycle time for loading, expanding, sizing and unloading is 40 seconds. Two hydraulic cylinders control mandrel feed and return through two draw rods. Size: 7 ft high, 40 by 36 in. at base; open height, 30 in. Other sizes available. *Walter P. Hill Inc., Detroit, Mich.*

Press Brake: Series A light-duty brake features variable-speed drive, providing 20 to 50 strokes per minute. Twin-plate bed provides lateral rigidity, minimum deflection, and a 1¼ in. slug clearance on multiple punching. Twin drive through double-reduction gear applies power over length of the ram; ram adjustment is motorized. Available in three sizes with capacities of 54 in. wide, 10 gage to 120 in. wide, 16 gage sheet. Each has a 3-in. stroke, 3-in. ram adjustment and 12-in. die space. *Dreis & Krump Mfg. Co., Chicago, Ill.*

Milling Machines: Ram type models No. 24 light, No. 24 medium, No. 28 and No. 38 medium, all feature adjustable cutterhead for horizontal, vertical and angular milling. Units have large tables, saddles and knee assemblies and heavy rams. Load meter prevents overloading and shows when cutter is becoming dull. *Van Norman Co., Springfield, Mass.*

Portable Bender: Bends from ½ to 1¼-in. IPS pipe to 180 degrees. Toggle switch controls forward or reverse rotation of the bend. Averages 60 bends per hour with one

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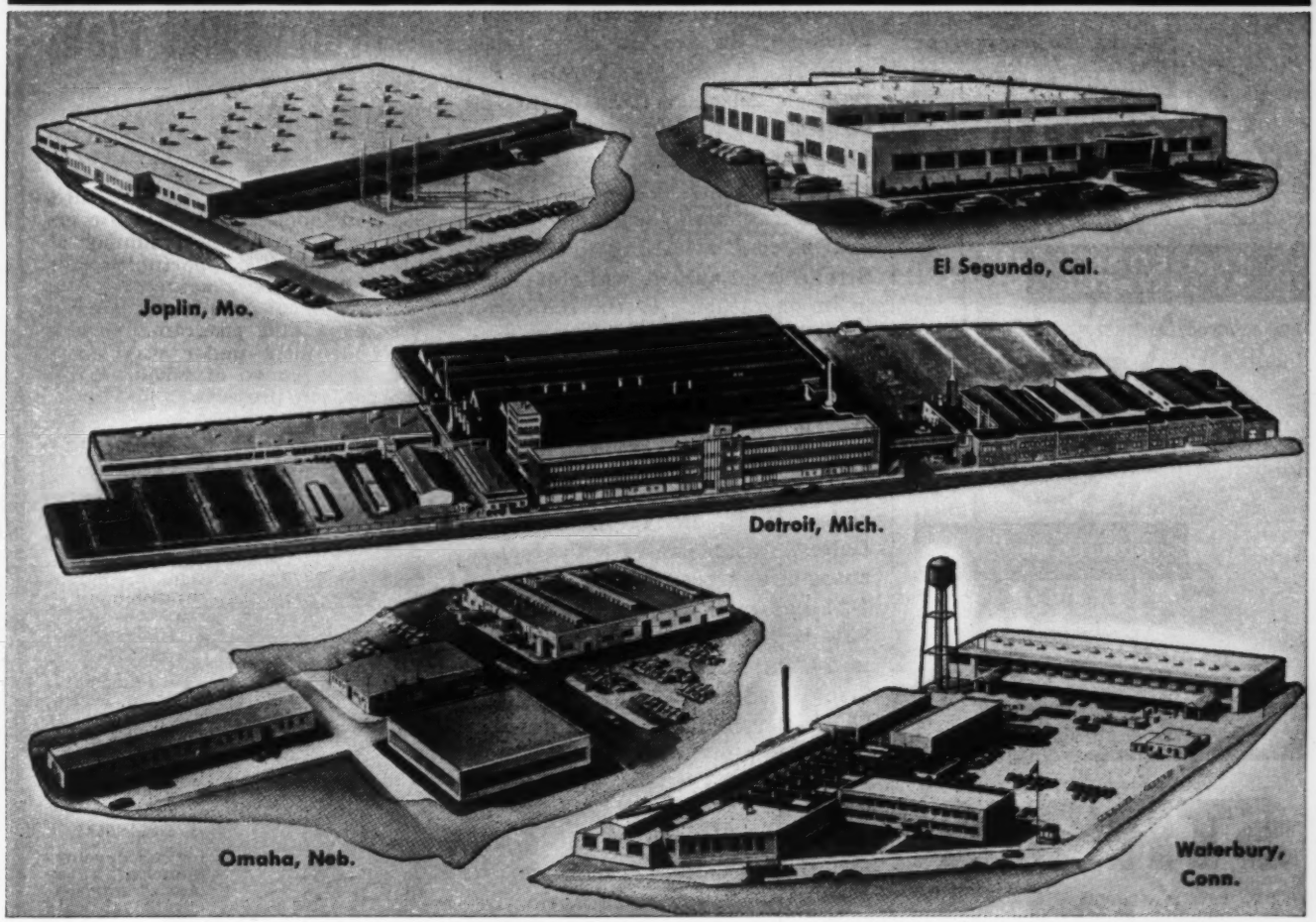

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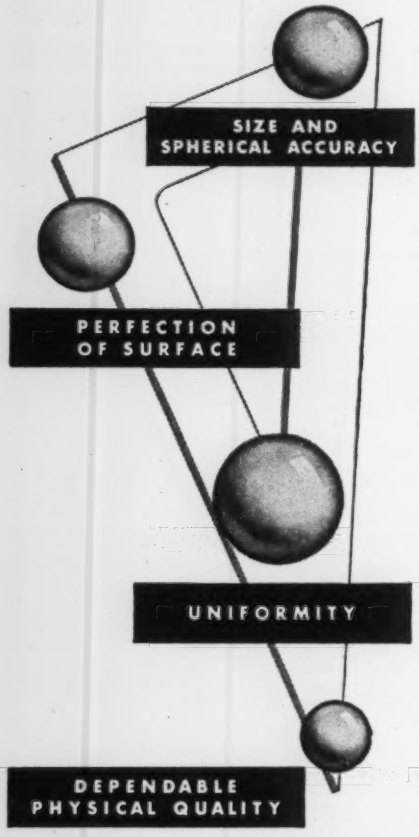

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New Machines

operator. Can be placed along a length of pipe and operated at that location. *Wallace Supplies Mfg. Co., Chicago, Ill.*

Shaper: Made by A. B. Prema Maskiner, Sweden, in three sizes, with 10, 11 or 13-in. stroke. Six ram speeds range from 30 to 150 strokes per minute. Six power feeds are provided. Features include hardened alloy steel gearing, antifriction bearings on all shafts, and swiveling tool head. Stroke is adjustable while machine is in operation. *Austin Industrial Corp., White Plains, N. Y.*

Milling-Routing Machine: Automatic tracer controlled Hydro-Router features hydraulic tracer servo control for positioning of vertical spindle slide, ram and ram slide. Hydraulic feeds have infinitely variable rates with stepless automatic tracer control. Model 1-24 has table working surface of 32½ by 14½ in.; longitudinal range is 24 in.; cross, 12 in.; vertical, 8 in. Feed rates adjust from 0 to 65 in. per minute. Spindle speeds range from 900 to 3600 rpm. Floor space required is 76½ by 47½ in.; approximate weight is 4300 lb. Larger units are available; special models built to specification. *Turchan Follower Machine Co., Detroit, Mich.*

Turret Lathe: Model No. 5 has 2½ by 12-in. bar at turning length; chucking capacity is 15 in. diameter. Has a planetary gear, hydraulically-actuated drive. In high-speed range, spindle speeds are continuously variable at practically constant horsepower; gears can be shifted instantly. Unit machines heavy parts at high speeds with close tolerances. *Morey Machinery Co. Inc., New York, N. Y.*

Automatic Welding Head: Model 944 features automatic control of both welding head and positioner. If used, high frequency pilot circuit is also automatic. Hardened steel feed rolls adjust for both solid and tube wire and accommodate any rod size from ⅛ to ¼-in. in diameter. Hold-down roll has integral tension arm. Feed nozzle is long wearing. Unit operates with any positioner or transformer; maximum current capacity

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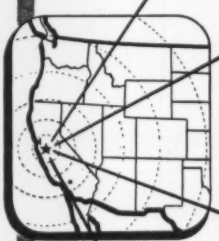

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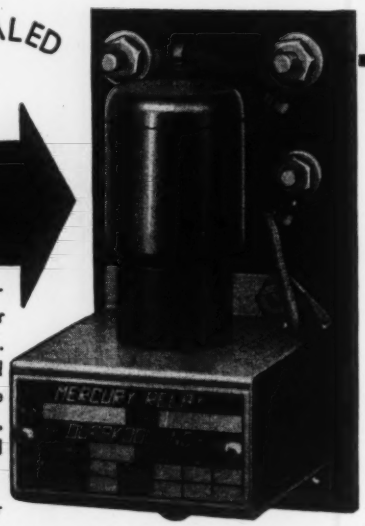

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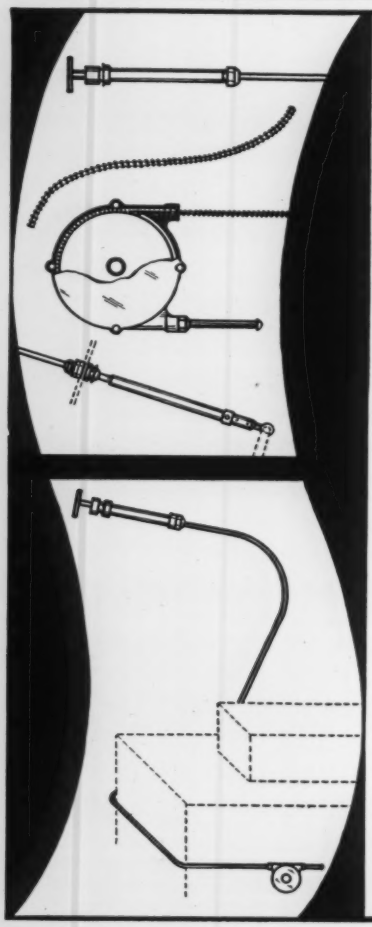

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Lathe: Features include heavy headstock, double V-belt outboard drive, ball bearing mounted spindle. Has 12-in. swing-over bed and saddle wings, 1-in. collet capacity, 1⅜-in. spindle hole, and center distances of 23 and 35 in. Sixteen spindle speeds range from 38 to 1260 rpm. Precision ground top surfaces on the cross slide and saddle permit mounting fixtures and the use of magnetic indicators. Bed has two V-ways and two flat ways precision ground to a tolerance of 0.0005-in. *Logan Engineering Co., Chicago, Ill.*

Automatic Drill: Model 14 Holomatic unit does single and multiple feed rate operations. Powered by compressed air and hydraulically fed, it is suitable for automatic or manual cycle control. Stroke is adjustable to 4 in. with ample thrust for ½-in. diameter drilling in steel. Positive stop with a dwell or instantaneous retract operation, continuous cycling, skip drilling, back feeding and manual jogging are possible. Air motors are available in various capacities to ¾-hp and speeds of 500 to 15,000 rpm. Units can be mounted horizontally, vertically or at an angle. *Hause Engineering, Montpelier, O.*

Grinder Head: Features angular adjustment in a vertical plane. Wheel speed is 3600 rpm. Cup wheels can be used to grind almost all clearance angles. Tooth rest remains on the center line of the cutter for almost all grinding on centers or in the work head, facilitating setup. Most cutters and

If your product is

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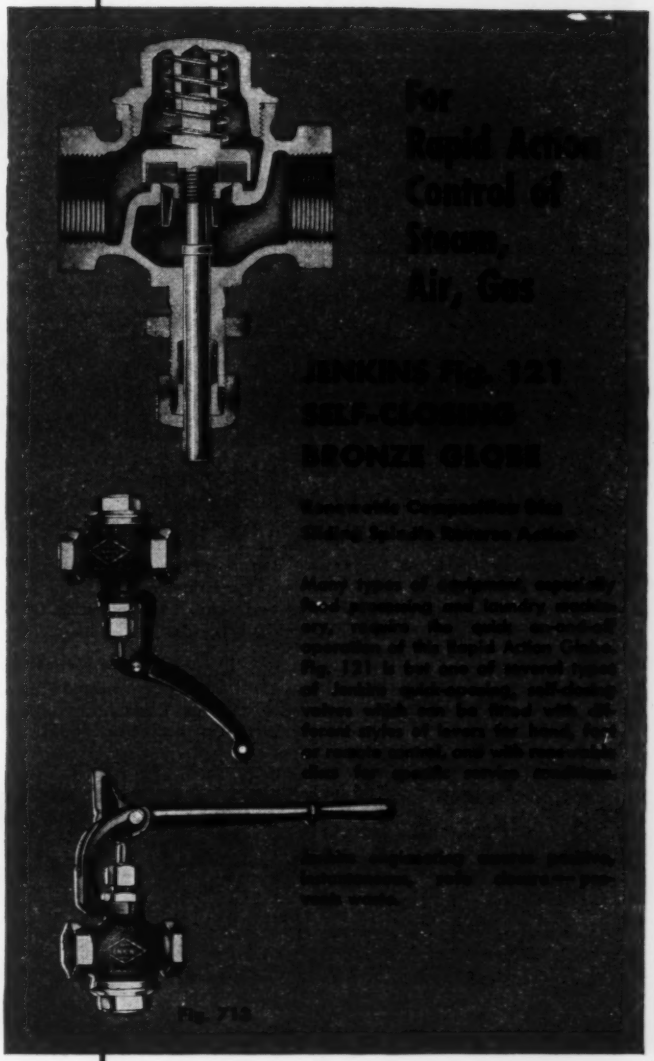
OR OTHER APPARATUS INVOLVING AIR, STEAM, WATER OR OTHER FLUID CONTROL



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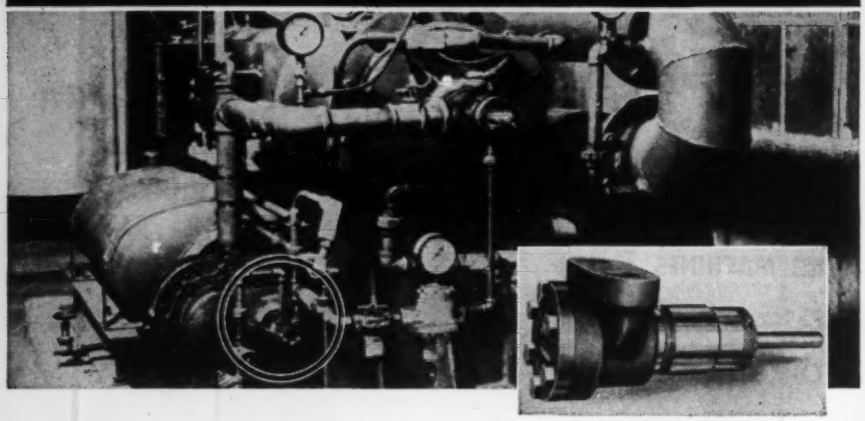
HOW ROOTS CONNERSVILLE USES THOUSANDS OF VIKING PUMPS



The Roots Connersville Blower Division, Connersville, Indiana, builds inert gas generators for many industries. Viking Pumps are standard equipment for pumping fuel oil, which is burned to produce cheap inert gas for preventing fires in explosive atmospheres. Uses range from gas and coke oven installations, steel works, oil refineries, chemical and rubber plants to fruit packing plants. In these applications thousands of Viking Pumps are being used with highly successful results.

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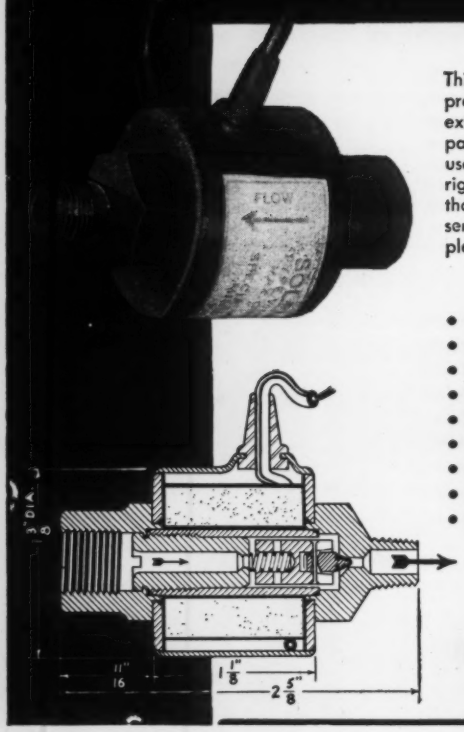
VIKING PUMP COMPANY CEDAR FALLS, IOWA

SOLENOID VALVES WITH ADVANTAGES PLUS



This valve of unique and practical design has proved itself in the past seven years to have extreme endurance and reliability. Important parts are stainless steel and no gaskets are used whatsoever. All parts silver brazed for rigidity. Look no further for a solenoid valve that will give years of trouble free, efficient service. Write today for full information. Samples available for inspection and test.

IMPORTANT FEATURES:

- All brazed construction
- No mounting brackets
- Weight 5 ounces
- Positive seal at any pressure
- Operates in any position
- Operates up to 1000 cycles per minute
- Power consumption 1 to 3 watts
- Pressure up to 200 p.s.i.
- Straight through flow

Specialty PRODUCTS CO., INC.
3725 Monitor Ave.
Minneapolis 16, Minn.

New Machines

reamers can be ground all over with one setup by the use of the swiveling table and the tilting head. All clearance angles are read directly in degrees from the scale on the head. *Pope Machinery Corp., Haverhill, Mass.*

Semiautomatic Mill: Features rapid approach, continuously variable cutting speeds and automatic return. Large diameter spindle has 15 speeds and is supplied with a choice of three spindle bores: No. 9 B&S, No. 10 B&S or No. 4 Morse taper. Two or three-slot tables are available; T slots are milled from solid. *Rotex Punch Co. Inc., San Leandro, Calif.*

Sheet Metal Fabricator: Model 10-AA punches, notches and nibbles. Hydra-New-Matic head operates with minimum vibration and noise at 165 strokes per minute for single hole punching and for nibbling. One holder permits ten-second changing of punches and dies for punching various round and shaped holes up to 1¼ in. in diameter; another holder provides for punching various round and shaped holes up to 3½ in. in diameter. Notching operations are performed without ram adjustments by placing notching unit on bed table. Built-in scales and gages on notching units are adjustable up to 5 in. for corner notches. Does all types of nibbling. Nibble lever controls nonrepeat device for continuous, uninterrupted ram operation during nibbling. *Wales-Strippit Corp., North Tonawanda, N. Y.*

Office Equipment

Duplicator: Duplicopy spirit type duplicator makes copies of typed, written or drawn material in as many as five colors simultaneously. Features Magic Fluid Flow, which distributes proper amount of liquid on moistening roller. Up to 300 copies can be made from a master. Model A-44 features automatic sheet feed and counting meter; model H-44 is manually fed. *Duplicopy Co., Chicago, Ill.*

Bookkeeping Machine: One entry by operator posts all records and enters each charge or credit simultaneously on all records. Prepares

a complete statement for accounts receivable, showing charges, credits and balances, as well as a complete ledger showing balance and detailed history of customer's activity for credit reference and a complete journal giving totals for sales analysis and control of receivables, cash receipts and discounts. Accounts payable ledger shows balances due and a complete history of transactions. Complete journal shows up-to-date analysis of purchases and expenses and controls on payables, disbursements and discounts earned. Can also handle payroll, showing earnings of each employee and complete journal with payroll distribution by departments. *Remington Rand Inc., New York, N. Y.*

Electric Duplicator: Model D-11 has power drive and power clutch. Machine will reproduce two copies per second of anything typed, written, drawn or printed through duplicating carbon, in as many as five colors in one operation. Copies can be made on any weight paper from 16-lb to heavy card stock and up to 8½ by 14 in. in size. Has disappearing receiving tray. Reversible feed tray facilitates handling of long and short sheets. Machine may also be hand fed. *Ditto Inc., Chicago, Ill.*

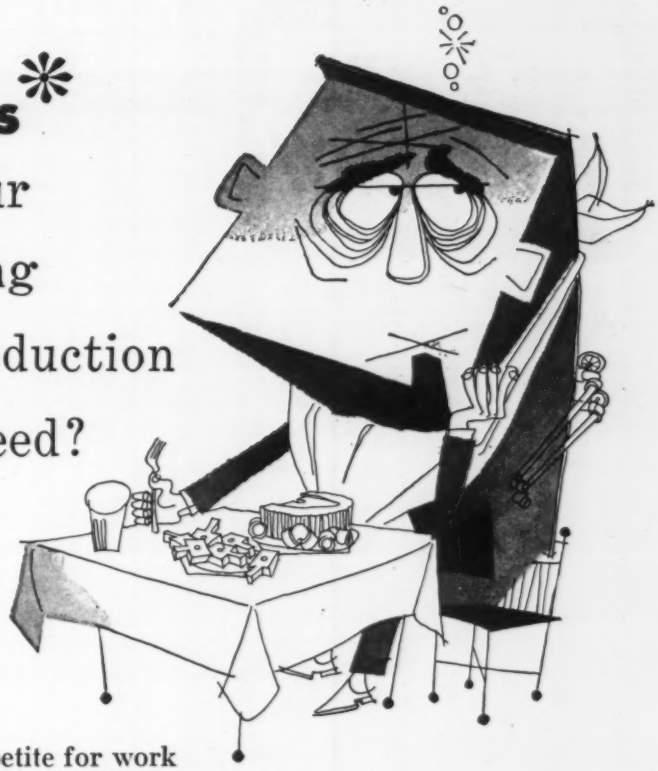
Plant Equipment

Automatic Strainer: Self cleaning unit is made in 2 to 36-in. pipe line sizes. Removes fine suspended particles from raw or process water and disposes of them automatically. Units constructed of special noncorrosive materials strain sea water, ammoniacal liquor, gasoline, oil and various other liquids. Strainer consists essentially of a rotating drum in which straining elements are held. Drum is mounted on a vertical shaft and housed in a cast iron body. Liquid to be strained enters through an inlet at the bottom of the housing, rises on the outside of the revolving drum and passes through the drum. Dirt and foreign matter remain on the surface of strainer elements, and clean liquid flows down the center of the drum to the outlet. By means of a back-

does

coil-itis*

have your processing tank production off its feed?



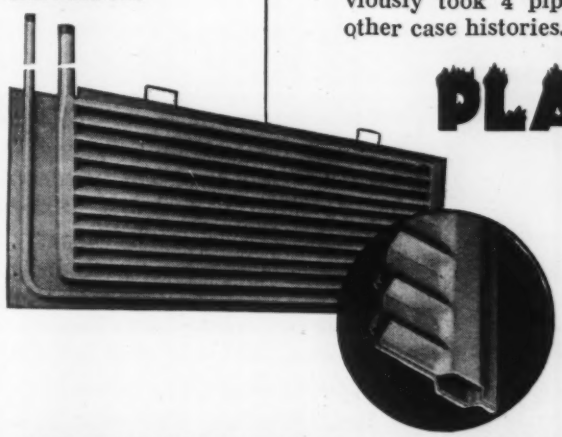
When the appetite for work of your heating and cooling processes diminishes, the trouble may well be coil-itis. For, downtime due to pipe failures and limitations can seriously delay your production flow. Switch to Platecoils, the new tonic for production, as revolutionary as the new wonder drugs. Platecoils take 50% less tank space leaving more room for greater payload. They heat or cool 50% faster. They simplify maintenance and save hours of downtime. Equally important, Platecoils cost as much as 50% less in the first place. Platecoils cure production troubles involving heat transfer and give production a shot in the arm.

Write for Bulletin P71 today!

PLATECOILS SAVE 50% IN HEAT TRANSFER COSTS

PLATECOILS ELIMINATE A 6-TO-8 HOUR-A-DAY CHIPPING JOB

At Sealed Power Corp., installation of Platecoils has completely eliminated a 6-to-8 hour-a-day chipping job. Three Platecoils now heat a tank that previously took 4 pipe coils. Ask about other case histories.



PLATECOIL

REPLACES PIPE COILS

*Coil-itis — Diagnosed as tank heating and cooling problems. Platecoils — the prescription for solving pipe coil problems.

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New Machines

wash orifice, foreign matter is flushed from the strainer elements. Drum rotates at a speed of 6 rpm, cleaning each row of elements every ten seconds. Straining media are constructed from stainless steel, bronze or porcelain. Unit removes suspended materials of extremely small size. *S. P. Kinney Engineers Inc., Carnegie, Pa.*

Air Compressor: Model 600 Super Unistage provides 600 cfm of air at 100 psi. Powered by a 150-hp induction motor; synchronous motors are available. Unit is vibrationless, can be installed without a foundation and can be moved from one location to another in a factory on a fork truck. Available with running water cooling or with cooling unit built in with or without a hood. *Schramm Inc., West Chester, Pa.*

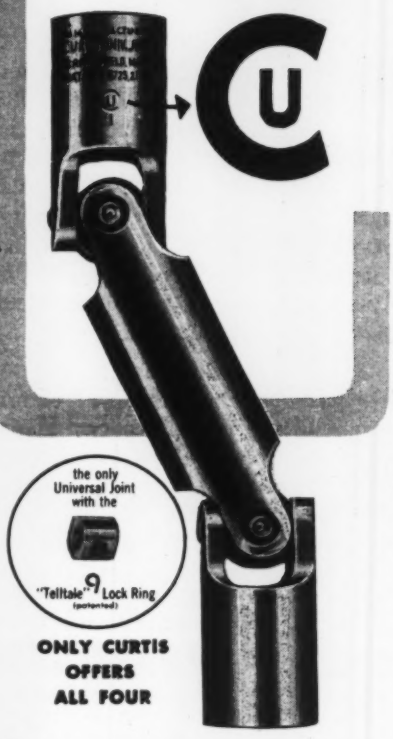
Automatic Filter: Compact unit rotates fresh filtering area into position while ejecting contaminant cake. Filtering screen material and size of screen opening can be supplied in monel, stainless steel, brass or bronze to fit requirements. May be used on an individual machine unit or as a central filter for many units. Capacity of filtration may be increased by adding filter drums in tandem. *Murray-Way Corp., Birmingham, Mich.*

Processing

Surface Finishing Machine: Model 202-A produces degrees of finish varying from flash removal to mirror finish. Has two-directional, electro-hydraulic feed mechanism and features straight-line actuation. Hydraulic circuits are totally enclosed, and antifriction bearings are sealed. Enclosed compressed air circuit opens and closes the rolls for unloading and also provides automatic float for the rolls as they follow the geometry of contoured work at any predetermined uniform pressure. Safety bar causes rolls to fly apart at light pressure. Horizontal design permits waist-high loading. Rolls are 40 in. wide, and diameters range from 4 to 9 in. *Clair Mfg. Co. Inc., Olean, N. Y.*

Heat Treating Furnace: Model 139DR features three separate

You benefit 4 ways when you insist on this mark



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PLUS — facilities and engineering skill to handle special specification jobs always available.

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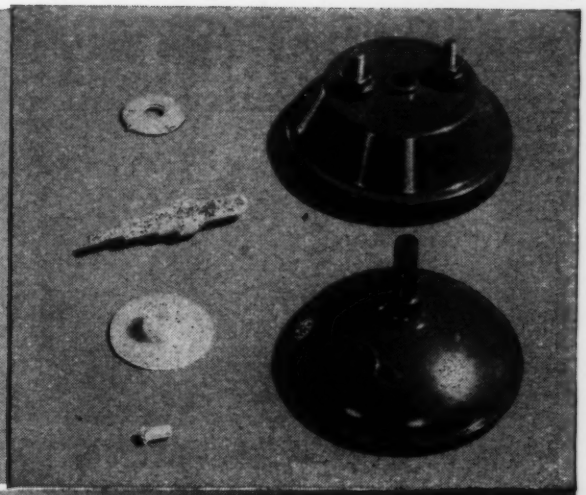
Parts of Du Pont nylon are strong, can't corrode, need no oiling...



...help automatic starter withstand vibration, give long, trouble-free service

Why not investigate how this unique engineering material—DU PONT NYLON —can help improve your product?

These six parts, as used in a new starter developed for automatic transmission cars, demonstrate how the unique properties of Du Pont nylon can help engineers develop more efficient products.

Du Pont nylon is strong and durable. Parts made of it withstand shock and vibration. Nylon can't corrode, is unaffected by most common chemicals. Du Pont nylon is light in weight, heat-resistant and remarkably resilient. Parts resist wear and abrasion, provide quiet operation with little or no lubrication. And Du Pont nylon's electrical insulating properties insure positive operation.

Perhaps the valuable properties of Du Pont nylon can help you develop a new or improved product or process. For further information on Du Pont nylon write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 1211, Du Pont Bldg., Wilmington 98, Delaware.

Check all these outstanding properties of Du Pont nylon—

- √ **TOUGHNESS**—Nylon is virtually unbreakable, even at low temperatures.
- √ **HEAT RESISTANCE**—Nylon is capable of continuous operation to 250°F.
- √ **ABRASION RESISTANCE**—Nylon resists wear, scuffing and gouging.
- √ **STRENGTH, RESILIENCY**—Nylon absorbs shock without chipping or cracking . . . is strong in thin sections.
- √ **LIGHT WEIGHT**—Nylon's specific gravity is 1.14.
- √ **CHEMICAL RESISTANCE**—Nylon is unaffected by most common chemicals.
- √ **LOW COEFFICIENT OF FRICTION**—Nylon has excellent bearing characteristics—provides quiet operation with little or no lubrication.

Nylon parts molded by United Plastics Industries, Inc., Vassar, Mich., for Automo Corp., Saginaw, Mich.

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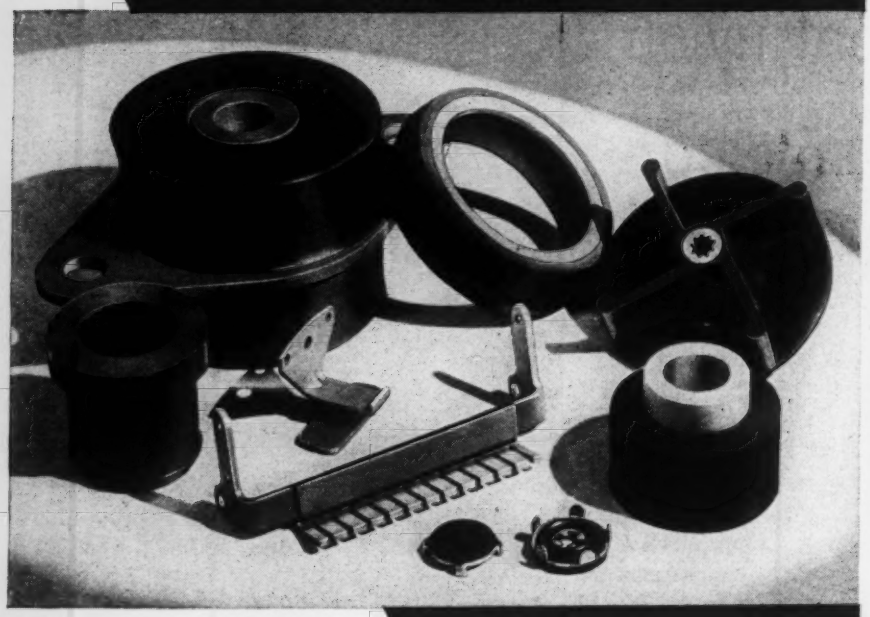
Better Things for Better Living
. . . through Chemistry

RUBBER-TO-METAL BONDING



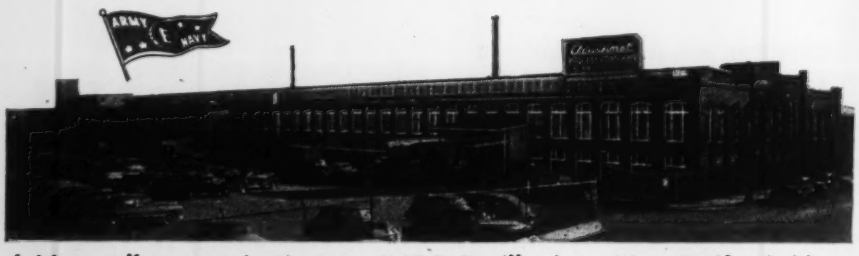
As a result of modern compounding, molding and adhesion techniques, many of which were developed in the Acushnet laboratories, the best properties of metal and rubber can be combined in one bonded unit to obtain strength, toughness and resiliency, as well as shock and vibration absorption, sound abatement, electrical insulation or conductivity, corrosion and abrasion resistance, and other desirable advantages.

Acushnet's specialization in this relatively new field involves the adhesion of rubber or synthetic rubber to metal in molds designed to accommodate the metal parts and which, in addition to bonding the rubber material to the metal, form and vulcanize the rubber in the same operation.

With extensive equipment and facilities for solvent degreasing, sandblasting, cementing and brass plating, Acushnet bonds rubber to metal by several processes, each suited to a particular application for the most efficient adhesion. Our engineers will gladly study your prints and make prompt recommendations.

Acushnet PROCESS COMPANY

Send for brochure "Rubber-to-Metal Bonding." Detailed information concerning applications, design, procedures, compounding, processes, bond strength ratings, etc. Illustrated.



Address all communications to 762 Belleville Ave., New Bedford, Mass.

New Machines

zones of temperature control. External controls permit regulation of temperature in any one of the zones, which are divided about equally over the furnace's length. This arrangement permits "on and off" operation during idling periods and high input when producing work. Readily controlled burners allow temperature variation in each zone for special heating needs. Furnace has a pilot light at each burner. Production rate of nonferrous metal parts is 1000 lb per hour. Heated work space is 15 in. in diameter by 10 ft long. Overall size is 16 ft long, 7½ ft high and 4½ ft deep. *American Gas Furnace Co., Elizabeth, N. J.*

Vapor Degreaser: No. 100 CS handles 200 lb of work per hour either in baskets or as individual pieces. Incorporates cool rinse, hot rinse and vapor degreasing; has both a rinse and boiling sump along with a water jacketed vapor area. Distilled solvent is collected by means of a condensate return trough, passed through a water separator and returned to the rinse sump. Boiling sump is fed by overflow from rinse sump. A 3000-w cloverleaf type Calrod unit, located in the floor of the sump, provides heating. As a solvent still, the unit has a distillation rate of 7 gph, based on a 30 per cent contamination of solvent. Available for 220-v, 60-cycle, single or three-phase; 440-v, 60-cycle, three-phase; 550-v, 60-cycle, three-phase; or 110-v, 60-cycle, single phase operation. Size: 38 in. long, 18 in. wide, 42 in. high. *Phillips Mfg. Co., Chicago, Ill.*

Finishing Barrels: Model 4D deburrs and burnishes components such as small screw machine parts and stampings. Has four removable tumble drums. Any drum can be removed for filling and emptying while the remaining ones are in operation. Four different finishes can be produced simultaneously. Drums are available with perforated sides for wet tumbling or solid sides for dry or wet tumbling. Solid sided drums are also available with rubber linings for ball burnishing. Model LD4 has four octagon shaped tumble drums for larger pieces or greater production. *Preakness Inc., Newark, N. J.*

THREE DURABLE FIN CALROD UNITS furnish heat for this Lintern air conditioner mounted in a crane cab at the National Tube Division plant of U. S. Steel, Lorain, Ohio.

Three G-E Fin Calrod* heaters outperform 6 ordinary heaters

Lintern Corporation cuts bulk, adds durability to steel-mill crane cab air conditioners

Three G-E fin Calrod heaters provide the same heat as the six heaters formerly used in air conditioners manufactured by the Lintern Corporation, Painesville, Ohio. Not only is weight saved and size reduced, but durability of General Electric fin Calrod units has led to reduced maintenance expense for Lintern customers.

Mr. James Lintern, the firm's vice-president, reports that the fin Calrod heater's oxidation- and rust-resistant finish withstands the corrosive steel-mill atmospheres, thereby reducing replacement expense. The fins are securely brazed to the heater to provide efficient heat transfer and to minimize vibration when the unit is subjected to high-velocity air.

Compact size, versatility, and ease of installation are added reasons for Lintern's use of G-E heaters. These heaters can be formed into a variety of shapes, making possible application to small or odd-sized areas.

The Lintern Corporation is one of the many companies that have found Calrod heaters result in better products at lower cost. To make sure *you* have the best in fast, clean, economical heat, contact your nearest G-E Apparatus Sales Office for the services of a Heating Specialist. His knowledge of the applications of electric heat to industrial products is your answer to improved product performance. For more information on G-E heaters mail the coupon at right.

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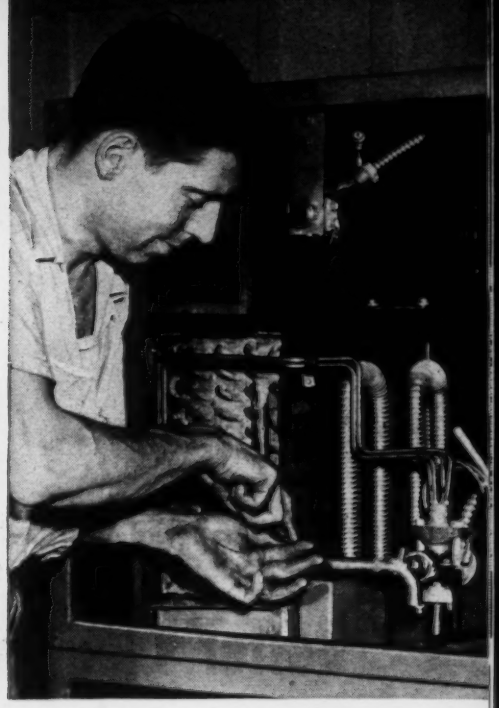
You can put your confidence in—

GENERAL ELECTRIC



INSTALLATION IS EASY with the compact unit formed by two fin Calrod heaters used in this one-ton Lintern air conditioner.

HEAT TRANSFER IS EFFICIENT because the fins multiply one inch of heater into 10.3 square inches of radiating surface.

Section A720-121
General Electric Company
Schenectady 5, N. Y.

Please send me bulletins I have checked:

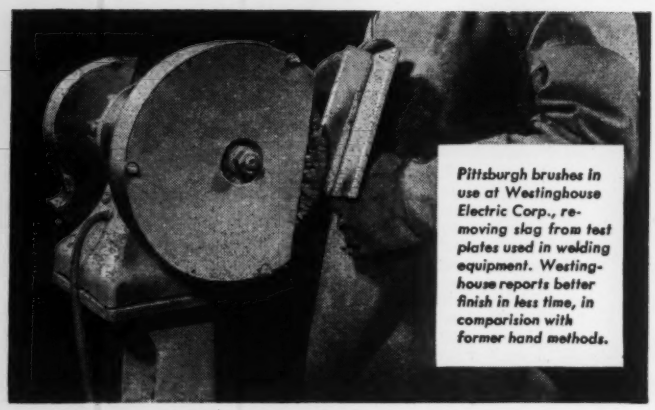
- ☐ For immediate project
- ☐ For reference
- ☐ GEA-5886, Calrod Heaters for Machinery Manufacturers
- ☐ GEC-1005, Complete Catalog of G-E Heaters and Devices

Name_____

Company_____

Address_____

City_____ State_____



Pittsburgh brushes in use at Westinghouse Electric Corp., removing slag from test plates used in welding equipment. Westinghouse reports better finish in less time, in comparision with former hand methods.

Replace hand finishing with power-driven Pittsburgh Brushes for

Better Cleaning Lower Labor Costs Fewer Rejects

—as these companies did:

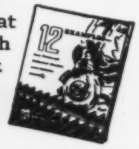
Removal of imbedded slag in welding test plates formerly was done by hand at the Westinghouse Electric Corp., Trafford, Pa., using a wire brush and welder's hammer. Pittsburgh brushes, powered by a direct-drive ½ h.p. motor, now remove more slag in less time, and produce a better finish. In addition, Westinghouse reports their Pittsburgh brushes "stand up better than average in use."

Complete cleaning of dried concrete, rust and scale from steel frames used in concrete forming is essential prior to re-using the forms. Pittsburgh wire brushes were installed at the Universal Form Clamp Co., Chicago. Working on a conveyor-fed machine, the Pittsburgh brushes now remove all foreign material at a rate of 50 pieces per hour, replacing former laborious hand brushing and scraping.

De-scaling preheated bar stock at the Dominion Forge & Stamping Co., Ltd., Canada, was formerly done by hand scraping. This never did a complete job, and inclusions resulted which produced defective forgings. Pittsburgh brushes, on specially-designed machines, now do the job, and have "increased efficiency, decreased the amount of scrap, improved work quality, and saved labor."

WRITE TODAY FOR FREE BOOKLET!

Write today for a free copy of our booklet that shows, through actual case histories, how Pittsburgh cuts brushing costs. Address: PITTSBURGH PLATE GLASS COMPANY, *Brush Div.*, Dept. W-5, 3221 Frederick Avenue, Baltimore 29, Maryland.



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MEN OF MACHINES

J. L. Gibson

Frigidaire Div. of General Motors Corp., Dayton, O., has appointed **J. L. Gibson** to the position of chief engineer, succeeding the late **S. M. Schweller.** Mr. Gibson graduated from Otterbein College in 1922 and joined the Frigidaire Div. engineering department in 1926. He became a section head in 1932 and was named manager of commercial and air conditioning engineering three years later. He has been assistant chief engineer since 1950. Mr. Gibson is a member of the Army Ordnance Association and the Engineers Club of Dayton.

Howard E. Van Scoyk has been named assistant chief engineer of the Frigidaire Div., in charge of household and commercial refrigeration and air conditioning, succeeding Mr. Gibson. A graduate of General Motors Institute, Mr. Van Scoyk has been associated with Frigidaire for 25 years.

♦

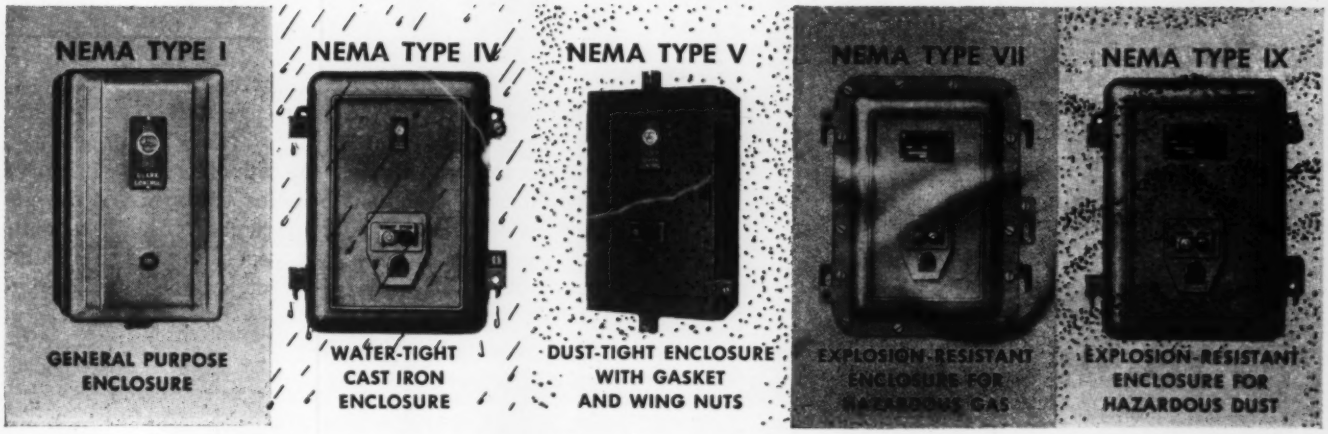
A graduate of the General Electric advanced engineering and test programs, **John H. Smedley** has joined the company's Carboloy department as design and application engineer in the permanent magnet products design and application section. The Carboloy department has also appointed **Bernard E. Speranza** as engineer in the carbide materials development section.

♦

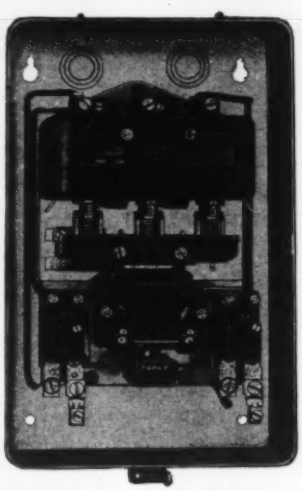
Peabody Engineering Corp., New York, has announced the promotion of **William F. Lange** to the newly established position of assistant chief engineer. Mr. Lange joined the company in 1946 as a design engineer.

♦

Alton D. Anderson has been named chief engineer of Cook Research Laboratories, a division of Cook Electric Co., Chicago. Mr. Anderson spent more than ten years as a research engineer and as chief of the pressure mechanisms development section of the Naval Ordnance Laboratory. Joining the Cook laboratories



for every operating condition
use CLARK TYPE "CY" STARTERS

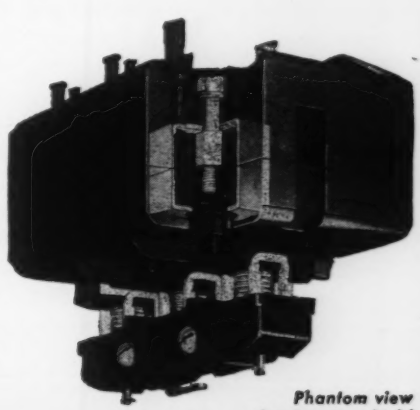


In every industry, including those where hazardous atmospheres prevail, CLARK TYPE "CY" STARTERS are giving utmost satisfactory service.

The incomparable new multi-turn magnetic blowouts combined with twin-break contacts, and the rest of the operating mechanism, are enclosed in types of cabinets to protect against adverse conditions or dangerous atmospheres.

Type "CY" starters, Sizes 2 and 3, employ an entirely new principle of arc interruption. The arc is extinguished by the effect of the blowout coil, concentric with the contact. The magnetic field quenches the arc either by lengthening or confining it. In its forced rotation it moves continually from a hot to a cold spot—minimizing burning or pitting of contacts. The ingenious design of the arc chamber prevents carbonization and the accumulation of hot gases between wiring terminals—minimizing phase-to-phase failures. Sizes 0 and 1 use the same general mill type construction as the larger sizes.

- No filing, dressing or cleaning of contacts!
- No tools necessary to inspect contacts!
- Easy to change moving contacts!
- Stationary contacts changed quickly!
- Remove only two screws and one pin to change coils!
- Remove only four screws to take out stationary magnet frame!
- Power circuit contacts available with springs in complete packaged service kits for ease in stocking!



Phantom view showing Arc-shield

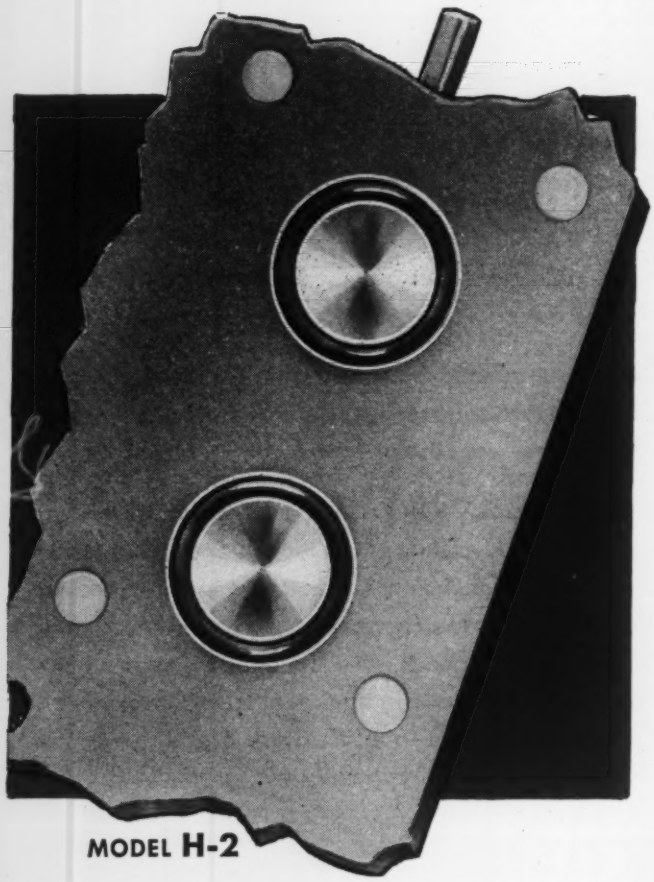
You'd better try CLARK TYPE "CY"

ENGINEERED ELECTRICAL CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152ND STREET, CLEVELAND 10, OHIO

New
HARTWELL
Push Button
Trigger Action
FLUSH LATCH



MODEL **H-2**

● A new latch development for modern equipment. Combines the desirable features of push button operation with the positive simplicity of trigger action in a small, rugged, lightweight yet inexpensive flush latch.

Available in many offset combinations for various door and frame thickness arrangements. Standard with or without gaskets in stainless steel or cadmium plated cold rolled steel.

Write for new 1954 Flush Latch Catalog

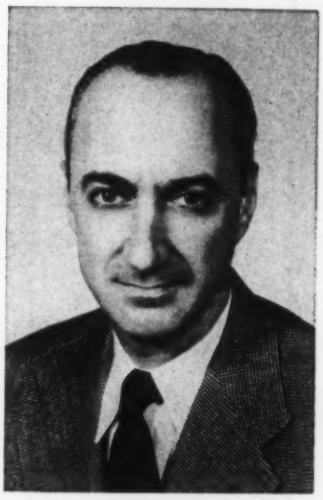
HARTWELL
COMPANY
Manufacturer of Flush Latches and Hinges, Fittings and Cable Terminals.
9035 Venice Boulevard, Los Angeles 34, California

Men of Machines

in 1950, he has served as director of the systems development section and, most recently, as assistant chief engineer.

Cook also announces the appointment of **Earl L. Washburn** as technical head of the systems development section. Mr. Washburn has been associated with the company for two years, and formerly held the position of senior project engineer at Wallace Tiernan Products Co.

♦



John W. Brennan

Formerly chief engineer, **John W. Brennan** has been elected vice president of engineering of the American Blower Corp., Detroit. Mr. Brennan joined the company in 1927, following graduation from the University of Notre Dame. He served in several of the company's branch offices and was named manager of the hydraulic coupling division in 1945. He was appointed chief engineer in 1951. Mr. Brennan is a past chairman of the Detroit Section of the American Society of Mechanical Engineers and a member of the Engineering Society of Detroit.

The American Blower Corp. has also appointed **A. F. L. Anderson** as chief engineer. He became associated with the company in 1925 and has advanced through various positions to director of design, the position he held until his new appointment.

♦

Lawrence E. Blazey has joined Grothe & Swanker Inc., Cleveland engineering firm, as staff consultant on industrial design. He will have charge of work in appearance design and product styling.

♦

With headquarters in Pittsburgh, **A. H. Candee** has joined the engine division of National Supply Co. as power consultant.

♦

Ralph Zimmerman, a product design engineer since 1942, has been promoted to chief product engineer by National Motor Bearing Co. Inc., Redwood City, Calif.

♦

George E. Rowbotham was recently appointed chief draftsman of the Chandler-Evans Div. of Niles-Bement-Pond Co., West Hartford, Conn. During the past 18 years he has served in various engineering capacities with Curtiss-Wright Corp., General Motors

Enough dust to stop 102 ordinary motors

Let just a pinch of these gritty particles inside a motor bearing and the result is always the same . . . bearing failure. The motor stops . . . production ceases.

Dust is busy ruining the bearings of ordinary motors all the time. Almost every time an ordinary motor is greased on the job, little powdery, abrasive specks are pumped into the bearing along with the grease.

Life-Line* motors lick this problem with sealed, pre-lubricated bearings. These bearings are packed with grease in dust-free rooms at the bearing manufacturer's plant. Then the bearing is completely sealed (not just shielded). The lubricant stays in . . . gritty dust stays out because you never have to grease a Life-Line motor.

Life-Line

The pre-lubricated bearing is one of the many features that make Life-Line motors the answer to lower operating and maintenance costs.

REMEMBER: The way to grease a *modern* motor is DON'T!

*Trade-Mark

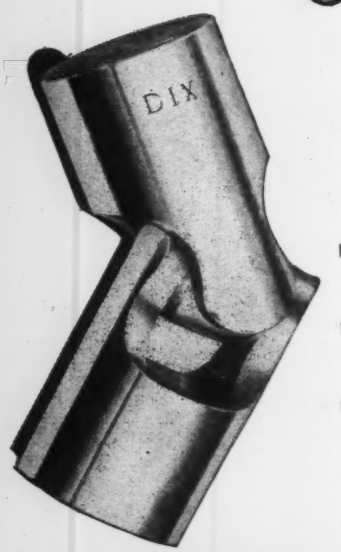
J-21721

YOU CAN BE SURE...IF IT'S

Westinghouse

PHOTOMICROGRAPH OF INDUSTRIAL DUST, MAGNIFIED 100X. COURTESY CASE INSTITUTE OF TECHNOLOGY.

What Features do YOU WANT in a Universal JOINT?



- ✓ Maximum strength and bearing surface
- ✓ Quick-acting, dependable response
- ✓ Long service-life
- ✓ Optimum operating angle
- ✓ Close quarter operation
- ✓ Accurate surface grinding
- ✓ High concentricity
- ✓ Minimum weight

LOVEJOY HAS THEM ALL!

Available in 13 standard sizes—diameters ½" to 4" —bores ¼" to 2"—lengths 2" to 10⅝"

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LOVEJOY FLEXIBLE COUPLING CO.

5018 W. Lake Street Chicago 44, Illinois

Manufacturers of flexible couplings, universal joints, variable speed pulleys and variable speed transmissions.

Men of Machines

Corp. and Ford Motor Co. In his new position Mr. Rowbotham will direct design, drafting and specification activities of the division.

♦

With responsibility for engineering work connected with atomic energy projects, **Theodore Jarvis** has been promoted to assistant chief engineer of Ford Instrument Co., division of the Sperry Corp., Long Island City, N. Y.

♦

Furane Plastics Inc., Los Angeles, has announced the appointment of **Wesley E. Weber** as a development engineer.

♦

Harlow D. Adkins has been promoted to assistant chief engineer of Kearfott Co. Inc., Clifton, N. J., and **Robert C. Rosaler** succeeds Mr. Adkins as head of the mechanisms laboratory.

♦

Acme Steel Co., Chicago, has announced the appointment of **Carl Persson** as assistant chief engineer of the machine design engineering department and **Hugo H. Gustafson** as assistant chief engineer of the production engineering department at the company's plant in Riverdale, Ill. Mr. Persson joined the company in 1937, and Mr. Gustafson, in 1929. Both men have served in various engineering positions.

♦

Included among recent promotions at the South Bend, Ind., plant of the Torrington Co. are those of **John A. Toth,** formerly chief engineer, who is now assistant general manager, and **Walter Fisher,** previously assistant chief engineer, who has been named chief engineer.

♦

Robert C. Cheek has been named to fill the newly created post of assistant manager of engineering for the Electronics Div. of Westinghouse Electric Corp., Pittsburgh. Mr. Cheek joined Westinghouse in 1939 and has served as a consultant on power system problems and as a specialist in carrier and microwave applications.

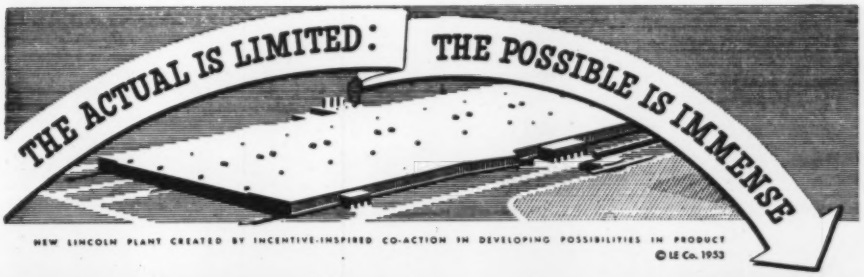
♦

Edward D. Heins has been named chief engineer of the export division of Chrysler Corp., Detroit. Recent appointments in the missile branch of Chrysler's engineering division include **C. Allan Brady** as chief liaison engineer; **John P. Butterfield,** chief design engineer; **Laurence M. Ball,** chief laboratories engineer; and **Bernard J. Meldrum,** staff engineer.

♦

Robert Masters has been appointed production engineer, and **Robert Van Houten** has been placed in charge of production development and control at the Fusite Corp., Cincinnati.

(Advertisement)



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT
© LE Co. 1953

11 WAYS to cut AC welding costs

DESIGNED for faster, simpler, more efficient welding, Lincoln's "Fleetwelder" saves money on every AC job. Here's how:

1. SELLS FOR LESS—Built with Lincoln incentive production methods, "Fleetwelders" low selling price gives *more range, longer service, easier, faster operation, greater dependability* for the dollar . . . to cut your AC welding costs.

2. Complete Overload Protection—Built with *generous* reserve capacity for long sustained output at high currents, "Fleetwelder" is *completely protected* against damage due to overheating *by a thermostatic controlled magnetic starter* . . . a feature exclusive with Lincoln.

3. Exclusive "Arc-Booster"—Pioneered by Lincoln, the exclusive "Arc-Booster" blasts the end of the electrode with extra amps for an instant when the electrode touches the work to start the arc automatically. Ideal in out-of-position welding.

4. Completely Safe—No high frequency devices as on some welders to help arc starting. Open circuit voltage is only 71 volts. Output terminal panel recessed to eliminate accidental shorting of leads.

5. "Low Voltage" Safety Relays available for special work. (Optional extra.)

6. Takes Less Power—"Fleetwelder" draws less amps in idle current than required for other AC welders. Inbuilt power factor is higher. Has pilot light to indicate power is on.

7. Low Maintenance—Ventilated from the top, "Fleetwelder" operates cleaner . . . needs less attention. Coils are permanently anchored, cannot become loosened to wear the insulation and short out. Easy accessibility to all working parts.

8. Current Stays Set—Once set, current settings do not change . . . are "locked" in position by rugged drum type holding devices. Illuminated dial shows setting of welding current.

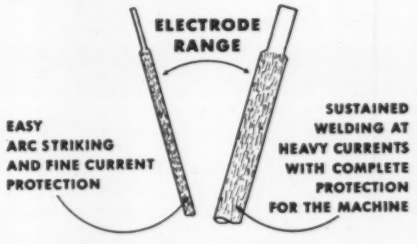
9. Steady Arc—"Fleetwelder's" reactor control is a free circuit designed for high responsiveness to changing arc conditions.

10. Compact, Portable—Only 35″ high, 22″ x 26″ at base, "Fleetwelder" requires less space. Has connection for simple hookup to 220 or 440 volt line. Can be furnished with three wheel undercarriage for moving around the shop.

11. Instant Penetration—The extra current for arc striking also gives *complete penetration* at once . . . no more cold overlaps or partial penetration at the start of the weld.

TODAY'S MOST ADVANCED AC WELDER.
"Fleetwelder", available in 300, 400, and 500 amp sizes, gives you

EXTRA RANGE TO SAVE EXTRA DOLLARS on light and heavy work


ELECTRODE RANGE
EASY ARC STRIKING AND FINE CURRENT PROTECTION
SUSTAINED WELDING AT HEAVY CURRENTS WITH COMPLETE PROTECTION FOR THE MACHINE

LOOK at the sketch. It shows *how* you benefit through "Fleetwelder's" wide current range in which maximum welding currents are 15 times minimum current values.

This *extra range* teamed with "Fleetwelder's" exclusive "Arc-Booster" insures fine currents *with instant arc striking* for light gauge jobs while with the same welder you have ample amps for sustained welding at high currents.

No other AC welder offers this cost cutting combination . . . and at such low cost.

INVESTIGATE "FLEETWELDER" TODAY—See what new advancements in faster, more efficient welding are being put to use by Lincoln to simplify and speed your operations and cut your welding costs.

SEND FOR FREE BULLETIN 1314 *on "Fleetwelder". Available by writing on your letterhead to Dept.* 1109

THE LINCOLN ELECTRIC COMPANY
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THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

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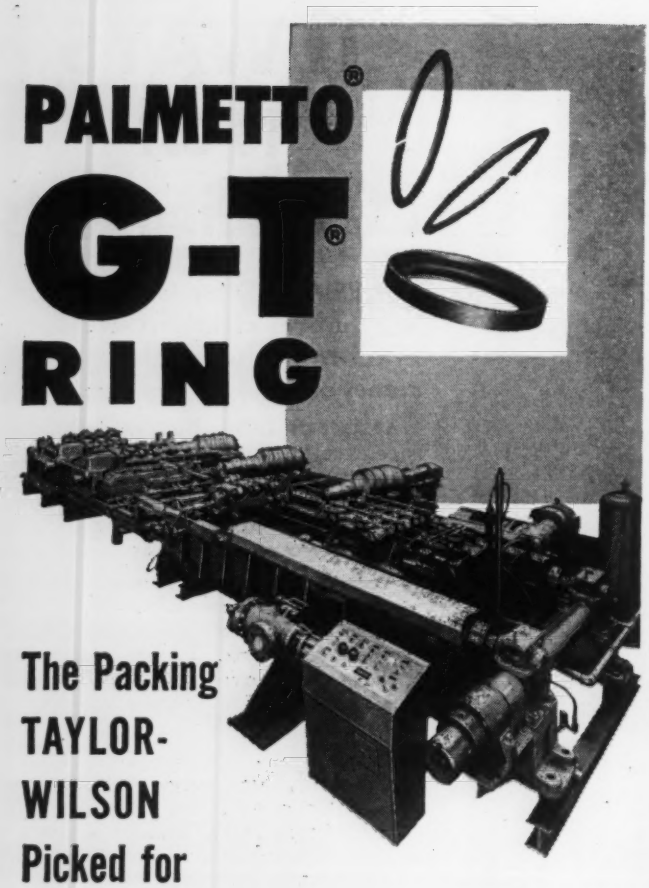
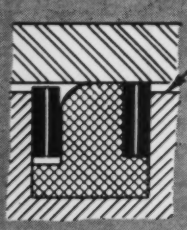


The Packing
TAYLOR-
WILSON
Picked for

"PRESSURE-PLUS"

In Taylor-Wilson's Automatic Hydraulic Pipe Testing Machine, the main packing problem was that of pressure. Non-extrusion at 3000 psi-water was the requirement. The G-T Ring was used successfully in a Youngstown Sheet & Tube Co. installation and in a pipe-tester later installed for the National Tube Co., a division of U. S. Steel Corporation. It has been "under pressure" for Taylor-Wilson ever since!

CANNOT EXTRUDE, *because*



As pressure is applied, conventional packings soon extrude into clearance space Y, then fail. Not so the G-T Ring! Because of its design consisting of a resilient sealing ring in a T-Section supported on each side by two non-extrusion rings, it cannot extrude. As pressure is applied to the G-T Ring, the resilient material flows under the non-extrusion rings, urging them against the cylinder wall and blocking the path of extrusion.

In pressure applications, dynamic or static—pick Palmetto G-T Ring—the packing **designed expressly for** non-extrusion.

OUR 90th YEAR
NEARLY A CENTURY OF *Quality*

Write for literature on Palmetto Molded Packings for more information on G-T Ring and other specialized molded packings.

PALMETTO Packings

packing more performance into every application

GREENE, TWEED & CO. North Wales, Pa.

THE ENGINEER'S Library

Recent Books

Mechanical Vibrations. *By William T. Thomson, professor of engineering, University of California; 264 pages 5½ by 8½ inches, clothbound; published by Prentice-Hall Inc., New York; available from* MACHINE DESIGN, $6.00 *postpaid.*

Presenting the fundamentals of vibration theory, this second edition assumes that the reader has an elementary knowledge of calculus, dynamics, and strength of materials. The first five chapters of the book deal with the behavior of the lumped system with one and two degrees of freedom, along with discussions of vibration measuring instruments, vibration absorbers, theory of balancing, and vibration isolation. Chapter six deals with lumped systems having many degrees of freedom. Elastic bodies are covered in chapter seven including longitudinal and torsional vibration of rods and lateral vibration of beams. The final chapter on electromechanical systems and analogies emphasizes the procedure to employ in circuit analysis.

♦

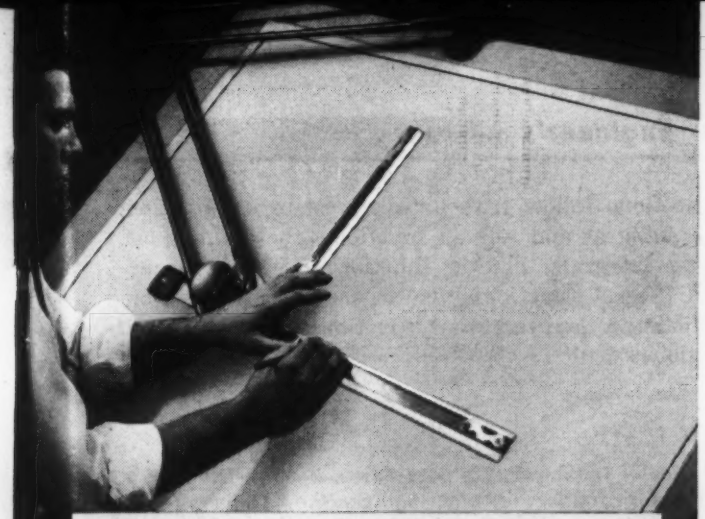
Circuit Theory of Electron Devices. *By E. Milton Boone, professor of electrical engineering, Ohio State University; 491 pages, 6 by 9 inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, $8.50 *postpaid.*

Written primarily for the engineering student, the fundamental emphasis of this book is directed toward circuit theory with the exclusion of the physics of electron devices. Diodes, triodes, tetrodes, pentodes, gas-filled tubes, single and polyphase rectifiers, and transistors are thoroughly discussed. Audio amplifiers, power supplies, tuned rf, band pass, and rf power amplifiers, oscillators, modulation, and demodulation are subjects also included.

♦

Tables of Functions with Formulae and Curves. *By Eugene Jahnke and Fritz Emde; 398 pages, 5½ by 8½ inches, clothbound or paperbound; published by Dover Publications, New York; available from* MACHINE DESIGN; $1.90 *paperbound,* $3.95 *clothbound.*

Originally published in German in 1909, this fourth edition printed in both German and English is written for engineers and designers engaged in practical computations involving the higher functions. Introduced with the sine, cosine and logarithmic integrals,



Instead of starting all over again

...he begins here

Here's how the Lukens Steel Company, Coatesville, Pa., uses Kodagraph Autopositive Paper to eliminate retracing in preparing flow diagrams and piping layouts.

These diagrams and layouts must also show the floor plans and fixed equipment installations of the departments involved. But instead of retracing this information from the basic plant layout drawings, Lukens Steel simply reproduces the drawings on Kodagraph Autopositive Paper—gets *positive, photographic* duplicate tracings directly.

This gives the draftsman a tremendous head start . . . for he only has to add the new detail to the Autopositive print . . . *and another job is done instead of being barely begun.*

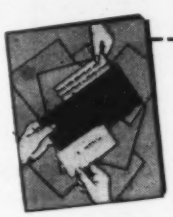
Low-cost Autopositive reproductions are made this easily at Lukens Steel:

Kodagraph Autopositive Paper is exposed with the drawings in a direct-process machine . . . and processed in standard photographic solutions. A fast, convenient room-light operation that produces positive photographic intermediates *without a negative step . . . without a darkroom.* These intermediates, in turn, assure highly legible prints.

Lukens Steel Company also uses Kodagraph Autopositive Paper *to produce print-making masters* from vendor blueprints; *to simplify filing,* by combining small vendor drawings on Autopositive intermediates in the standard Lukens drawing size; *to get low-cost protection* for original drawings which must be sent out of the plant.

Kodagraph Autopositive Paper

"THE BIG NEW PLUS" in engineering drawing reproduction.



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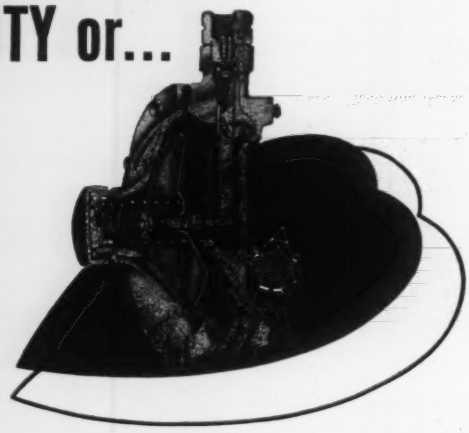

Why a good *SPRING* is necessary!

"This pressure reducing regulator is the HEART of the liquefied petroleum gas installation. On its performance depend the accuracy and reliability of the entire system . . . and the HEART of the regulator is the regulating spring which, because of its maximum length and large diameter, achieves super sensitivity and minimizes fluctuations in outlet pressures regardless of load demands."

Does this serve to make clear "Why a good spring is necessary"? Whether it's a comparatively simple or an infinitely complex piece of machinery . . . Automatic Spring Coiling Co. utilizes its superb *Engineering Ability*, the outgrowth of 30 years of spring specialization, to bring you the precision mechanical springs you need. Thus we are able to help you insure the successful and efficient performance of your product.

Make it a point to consult Automatic Spring Coiling Co. early in the job. Take advantage of our *Engineering Ability* to bring YOUR product up to peak operation with customized springs designed especially for you.

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ten sections follow that cover the factorial function, error integral and related functions, theta functions, elliptic integrals, elliptic functions, Legendre functions, Bessel functions, the Riemann-Zeta function, confluent hypergeometric functions, and Mathieu functions.

♦

Statically Indeterminate Structures. *By Chu-Kia Wang, associate professor of civil engineering, University of Colorado; 434 pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, *$7.50 postpaid.*

Material in this text is prepared to serve primarily as a workbook in the explanation of the basic principles and methods in the analysis of statically indeterminate structures. Techniques are described for determining deflections of statically indeterminate beams, rigid frames and trusses. An understanding of elementary calculus is required to benefit from the large number of illustrative problems which are worked in detail.

♦

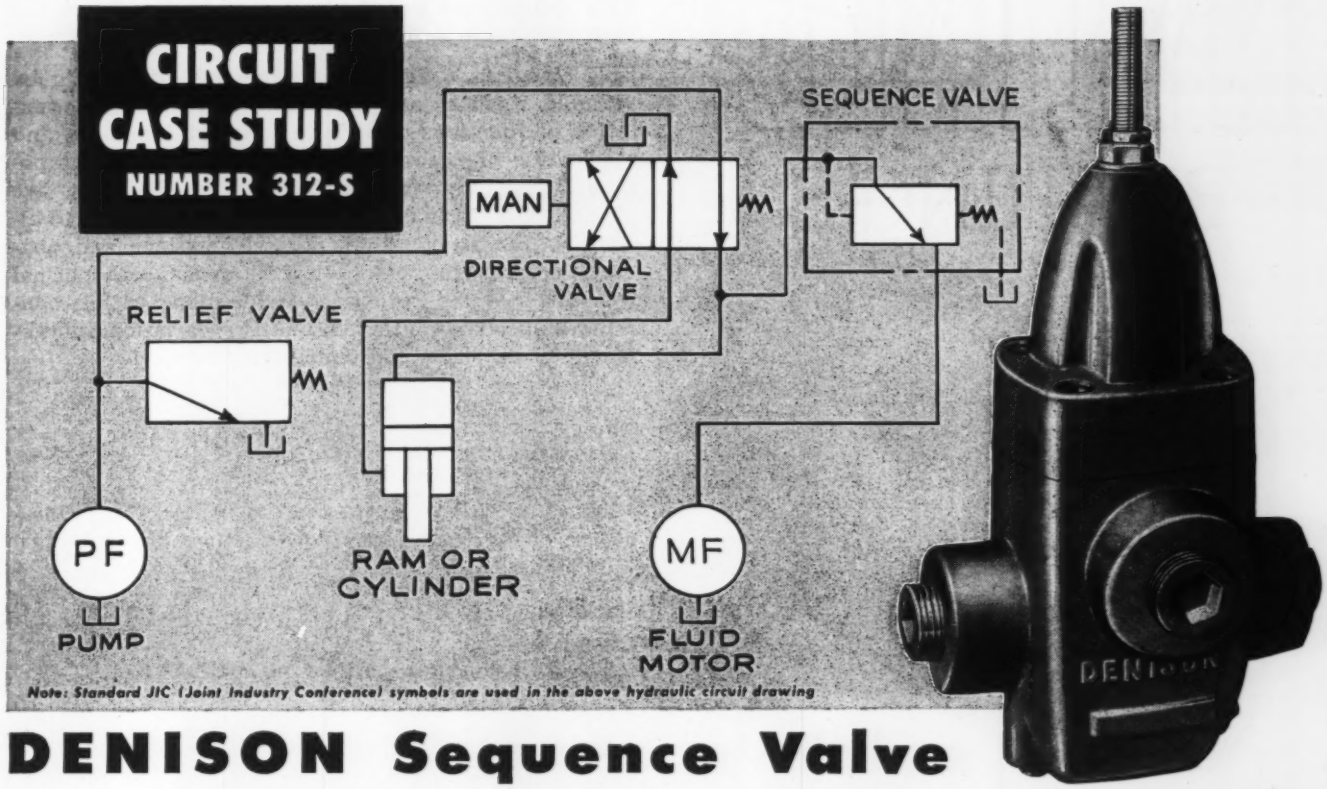
Gas Turbine Analysis and Practice. *By Burgess H. Jennings, professor of mechanical engineering, and Willard L. Rogers, assistant professor of mechanical engineering, Northwestern University; 495 pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, *$8.50 postpaid.*

Operation, uses, and probable future development of the gas turbine are covered in this text. First, developments of the internal-combustion engine and turbine are reviewed, followed by basic theory on thermodynamics, air properties, gas-turbine cycles, and thermodynamic analyses. Detailed information concerning gas turbine types and their design is included along with an extensive coverage of compressors of the axial-flow, centrifugal, and displacement types. The balance of the book embraces aircraft propulsion, jet engines, power plant and transportation turbines, fuels and combustion, stresses in turbine-plant elements, vibration, balancing, materials, and metallurgy.

♦

Mathematical Methods for Scientists and Engineers. *By Lloyd P. Smith, physics department chairman, Cornell University; 463 pages, 6 by 9 inches, clothbound; published by Prentice-Hall Inc., New York; available from* MACHINE DESIGN, *$13.25 postpaid.*

Covering a wide range of mathematical methods employed in solving technical problems, this book clearly illustrates conditions under which these methods are used. The first five chapters cover the elements of function theory, differential and integral calculus, space geometry, and line, surface, and mul-


CIRCUIT
CASE STUDY
NUMBER 312-S

Note: Standard JIC (Joint Industry Conference) symbols are used in the above hydraulic circuit drawing

DENISON Sequence Valve

controls oil flow to secondary circuit with *quick, direct action*

Above, you see a typical circuit utilizing a Denison **Sequence Valve** of the direct-operating type. Here, oil pressure is developed by a fixed-displacement pump. When the manual control of the directional valve is held open, pressure is directed to a cylinder, which performs the primary operation. As the piston rod of the cylinder meets resistance, pressure increases. When the increasing pressure equals pressure setting of the **sequence valve** (which is easily adjusted to any operating need) it acts upon a small pilot piston in the **sequence valve,** shifting the valve spool. Oil flow is now open to both the cylinder and to secondary operation, performed in this case by a fluid motor. Additional sequence operations could be provided in similar manner.

Pressure build-up at the primary operation brings quick action on the spool of the **sequence valve.** The pilot piston, which eliminates the need for heavy spring loading of the valve spool in circuits operating at pressures above 250 psi, is not employed in models designed for lower pressures. Instead, pressure acts directly against the valve spool, assuring high sensitivity to low-pressure changes. These **sequence valves** are externally drained.

Denison direct-operating **sequence valves** provide positive action at relatively low cost, for circuit pressures from 25 to 2000 psi, and are readily adaptable to remote control arrangements. Denison also makes hydrostatically-operated **sequence valves** for pressures to 5000 psi.

Denison direct-operating pressure control valves are available in a wide range of models, for relief, unloading, counterbalance and sequence needs —with or without remote control and built-in checks. All are available in ½, ¾, 1¼, 1½ inch sizes, for all pressures to 2000 psi. Choice of threaded, subplate, or flange connections. We invite your inquiry on circuit needs of this type — or write for bulletin VRD.

Denison offers one of the most widely practical lines of oil hydraulic pumps, motors and controls for circuits operating at pressures up to 5000 psi. Designed and built with skill and knowledge gained through twenty-five years of engineering leadership in oil hydraulics, they offer the compact ruggedness needed for exacting, heavy-duty demands. Wherever you need closely adjustable power and control with unlimited flexibility of application, specify Denison HydrOILic Equipment. Your request for information will not obligate you in any way.

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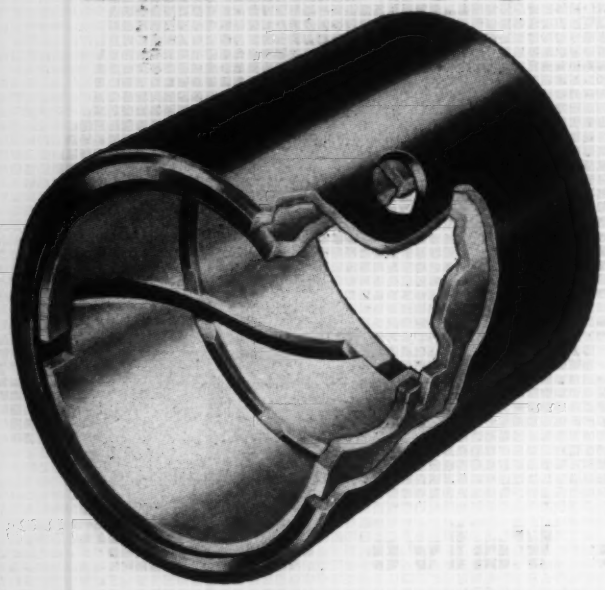

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*NYLINED Bearings have a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use.

For further information and the name of your local representative, write

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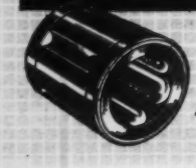

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The Ball Bearing for Linear Motions

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tiple integrals. Theory of functions of a complex variable, residues and complex integration, representation of functions by infinite series of functions, and application of functions of a complex variable to potential and flow problems make up the next five chapters. The remainder of the book is devoted to algebra of linear equations, transformations and quadratic forms, vector and tensor analysis, orthonormal function systems, orthonormal functions with a continuous spectrum, integral equation, variational methods, and elements of probability theory.

Association Publications

American Management Association Series. *This publication is* 6 *by* 9 *inches, paperbound; copies available from American Management Association,* 330 *W.* 42*nd St., New York* 36, *N. Y.,* $1.00 *each for members,* $1.25 *for nonmembers.*

The following publications are available:

Manufacturing Series

208. **Making the Most of Your Human Resources**—76 pages.

Packaging Series

42. **Advances in Packaging Material and Design**—56 pages.
43. **Practical Problems of Packing and Handling**—27 pages.

Government Publications

Guide for Patent Draftsmen. 16 *pages,* 8 *by* 10 *inches, paperbound; copies available from the Superintendent of Documents, U. S. Government Printing Office, Washington* 25, *D. C.,* 15 *cents.*

Selected rules of drafting practice relating to patent drawings are listed on the first two pages of this pamphlet. The remainder of the material is made up of perspective drawings of typical components which might appear in a patent drawing. Four pages are devoted to electrical and mechanical symbols and symbols for materials.

♦

NACA Technical Series. *Each publication is* 8 *by* 10½ *inches, paperbound, side-stapled; copies available from National Advisory Committee for Aeronautics,* 1924 *F St. N. W., Washington* 25, *D. C.*

The following Technical Notes are available:

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3003. **Investigation of 75-Millimeter Bore, Deep-Groove Ball Bearings under Radial Load at High Speeds—Oil Inlet Temperature, Viscosity, and Generalized Cooling Correlation**—33 pages.

3010. **Comparison of Effectiveness of Convection, Transpiration, and Film-Cooling Methods with Air as Coolant**—52 pages.

3011. **Co-efficient of Friction and Damage to Contact Area During the Early Stages of Fretting Glass, Copper, or Steel against Copper**—23 pages.

3017. **Axial-Load Fatigue Tests on Notched and Unnotched Sheet Specimens of 61S-T6 Aluminum Alloy, Annealed 347 Stainless Steel, and Heat-Treated 403 Stainless Steel**—28 pages.

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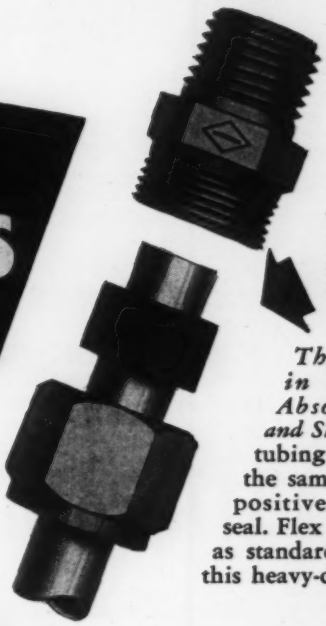
Got a tough tubing connection job?...

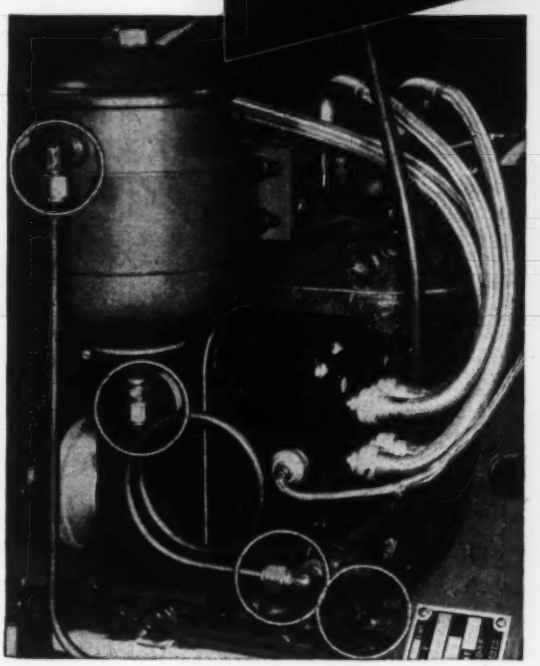
IMPERIAL FLEX FITTINGS

May Be the Answer

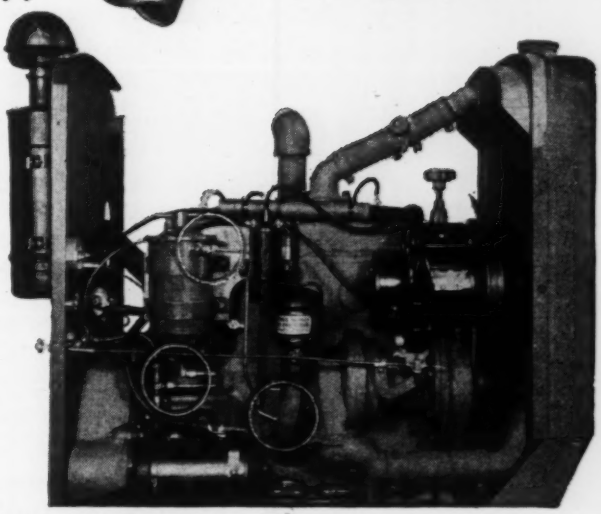


The tube coupling with vibration and shock absorbing sleeve.

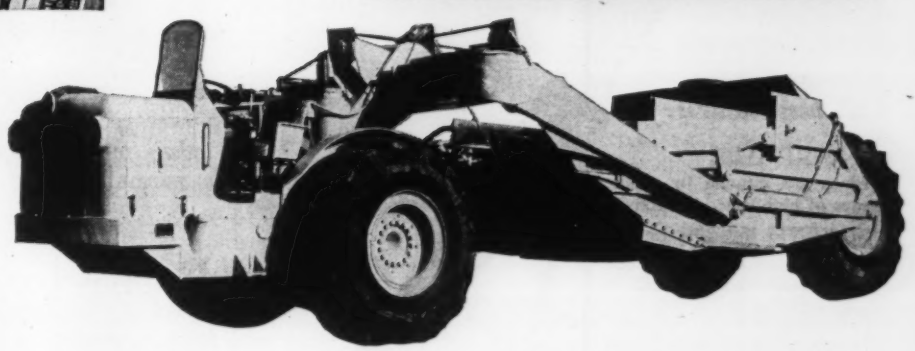
This Elastic Sleeve in Flex Fittings Absorbs Vibration and Shock . . . permits tubing to flex and at the same time assures a positive pressure tight seal. Flex Fittings are used as standard equipment on this heavy-duty engine.



Flex Fittings make joints virtually indestructible by VIBRATION . . . withstand SHOCK and MINOR TUBE MOVEMENT



Flex Fittings, circled on this engine, are very easy to install . . . simply slip nut and Flex sleeve over tubing . . . insert tubing into body as far as it will go and tighten nut—that's all.



Whether it's earth movers (illustrated), tractors, diesel engines, heavy power equipment or machinery, Flex Fittings will do the job. They have been thoroughly proved by extensive use.

Flex Fittings Can Be Used With All Kinds of Tubing

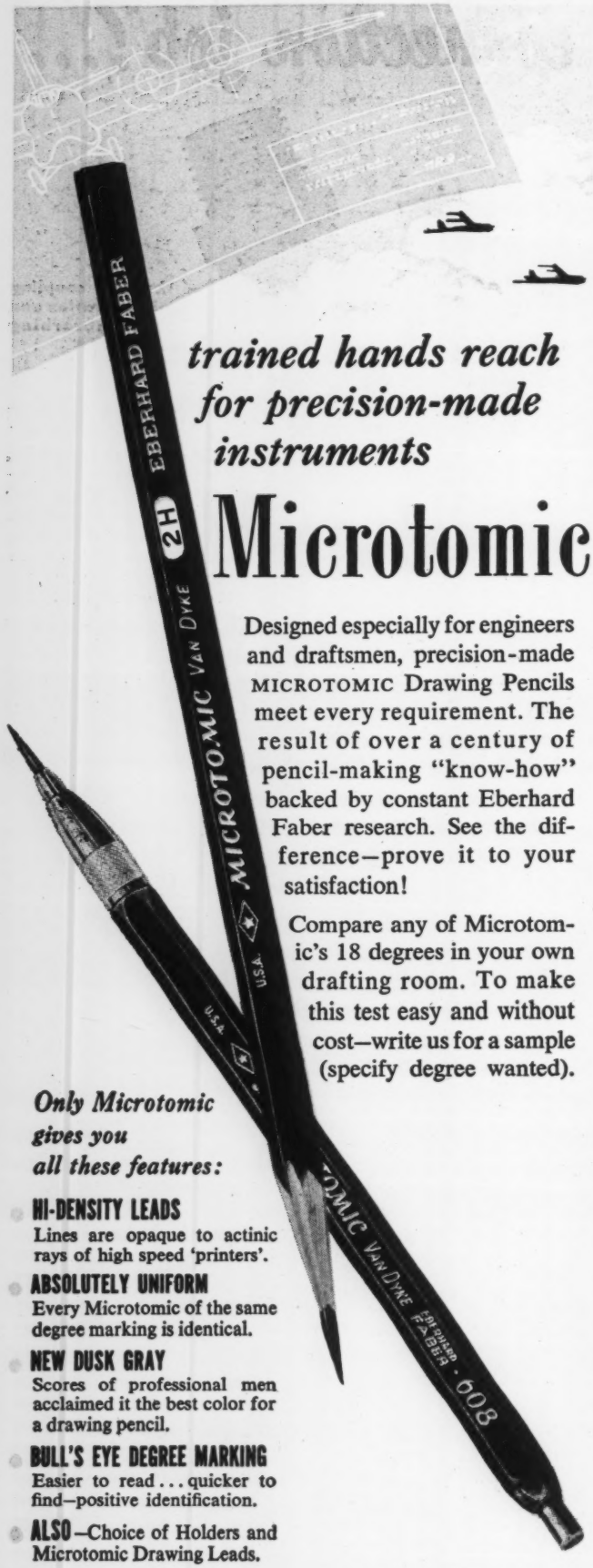
Imperial Catalog 344 gives you complete information on Flex Fittings. Ask for your copy.

THE IMPERIAL BRASS MFG. CO., 513 S. Racine Ave., Chicago 7, Illinois

In Canada: 334 Lander Ave., Toronto, Ontario

IMPERIAL

PIONEERS IN TUBE FITTINGS AND TUBE WORKING TOOLS



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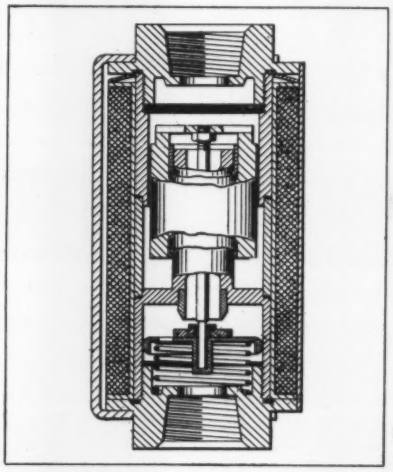
NOTEWORTHY Patents

ELECTROINDUCTIVE FLOW CONTROL for pneumatic systems is provided by a valve covered in patent 2,637,344 which utilizes the principle of magnetic repulsion for operation. Invented by Russell B. Matthews and assigned to Milwaukee Gas Specialty Co., the valve is designed for normally-open operation in a vertical pneumatic line. Flow through the valve is controlled by a sliding plunger, actuated by a solenoid coil, which holds the valve open by virtue of its weight. When the coil is energized, magnetic repulsion lifts

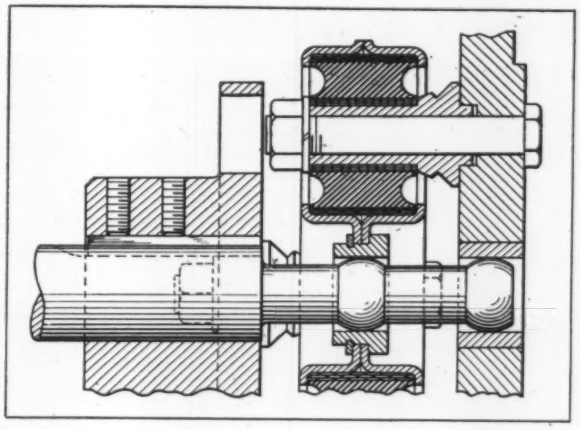


the plunger permitting a spring-loaded gasket to rise against the valve seat and seal off the flow. Travel of the plunger is limited by the interaction of two magnetic fields which establishes an equilibrium position. Advantageous features of the design include high initial actuating force, impactless operation, and low power requirements. Valve construction, which minimizes misalignment in operation, is also described in a normally-closed modification.

FRICTION LOCKING of yoke joints eliminates conventional rivets and increases resistance to torsional loads. Designed by Theodore O. Rueb and assigned to Sherman-Klove Co. under patent 2,636,759, hardened steel pins which have a knurled center surface to engage the tongue member are used to provide a secure friction connection for universal joints or other similar yoke attachments. Torsional loads at the joint are transmitted to the pins, minimizing deformation of the connected parts. Frictional engagement and retention of the pins are maintained by a flat leaf spring mounted in a broached slot. Flexibility in meeting performance requirements is provided by the pin design which does require heading after as-

sembly and can be prehardened or heat treated to meet prescribed strength requirements.

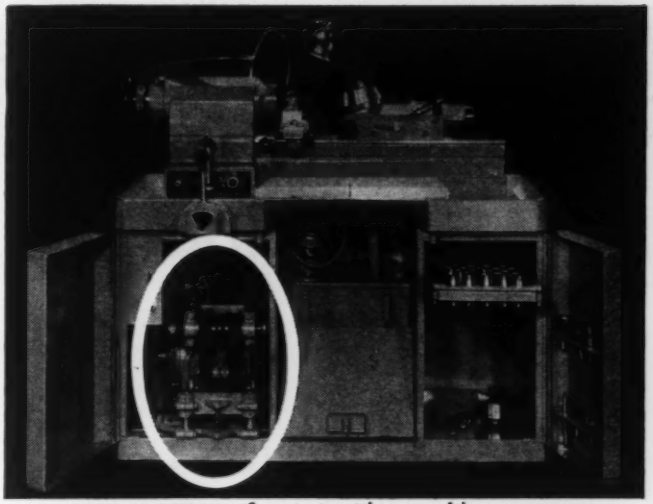
MINIMUM VIBRATION in high-speed drive connections is afforded by a flexible coupling which can be operated under angular misalignment. Designed by Earl F. Riopelle, the coupling of patent 2,633,719 utilizes a novel modified ball and socket connection at the end of the drive shaft which restricts rotation, regardless of direction, about a fixed centerline to produce balanced running characteristics. Flexibility is pro-



vided by preloaded rubber "biscuits", mounted in a separate carrier, which transmit power from the drive shaft to the driven member through bolted flange connections. Metal-to-metal driving contact is eliminated and displacement of the rubber absorbs torsional and angular deflections due to vibration and shock. Designed to limit axial separation of the members, the coupling is constructed to facilitate assembly and maintenance and is resistant to weather effects. The patent has been assigned to Morse Chain Co.

EXPENDABLE BEARING SLEEVES simplify assembly and maintenance of enclosed or inaccessible rotary shaft journals. Employed in a bearing construction designed by Charles L. Babb and described in patent 2,635,015, a split cylindrical sleeve rigidly clamped to the shaft acts as the wear absorbing element and is journaled in a rubber-lined insert in the bearing housing. Removal and replacement of the sleeve segments is readily accomplished without disassembly of the bearing housing or shifting of the shaft position. Necessity for precision bearing surfaces conventionally required is eliminated by the expendable design, simplifying production and reducing cost. Assignee of the patent is Allis-Chalmers Mfg. Co.

Copies of all patents presented in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.



EASY SELECTION of correct cutting speed is one reason

. . . Why lathe manufacturer chose Worthington's Allspeed Drive

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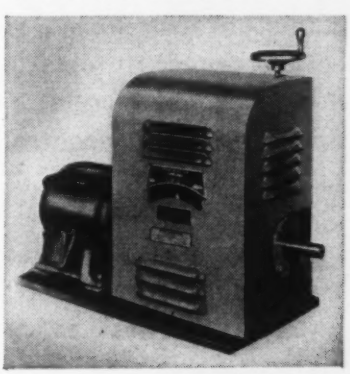
Infinitely variable speed changes are easily made on the Worthington Allspeed Drive by moving the speed control handwheel. Precise setting is indicated on a conveniently located dial. Allspeed Drives may also be operated by controls on the equipment in which they are installed. Power is transmitted through a mechanically adjustable tandem V-belt arrangement which provides stepless speed variations over whatever range you need.

Mountable in any position. Runs in either direction. Life-lubricated bearings throughout. All rotating parts fully machined and balanced. Automatic belt tensioning with no operative spring. Available in skeleton form, with cover or with built-in motor. For information on applications and specifications on Worthington Allspeed Drive, send coupon today.



ALLSPEED MOTOR DRIVES with exclusive two-belt design give you complete speed variation and an extremely compact unit for easy installation.

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